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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

AUTOMOBILE TORPEDOES.

THE HOWELL TORPEDO, PRESENT AND FUTURE EFFICIENCY OF AUTOMOBILES IN GENERAL, AND PROBABLE TYPE OF FUTURE TORPEDO CRUISER AND DESTROYER.

Three Lectures delivered to the Officers in attendance at the Naval War College, Newport, R. I., October 26, 27 *and* 28, 1892.

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In presenting the Howell torpedo it will not be amiss to enumerate the essential features which the automobile should possess.

These are:—1. Maximum speed within an effective range of not less than 400 yards.

2.—Efficiency to maintain a set depth and rectilinear direction in the horizontal plane.

3.—A maximum rending force. The whole to be embodied in a shell having a maximum strength with minimum weight of material. Upon this base and as the result of practice, the present general outline of shell for automobiles has been developed. It will be necessary

in the general description of nomenclature to give an outline of the principal factory tests in the several stages of assembling, in order that the various functions of its mechanism may be more fully understood.

DIMENSIONS.

Model of 1892.

Length from nose tip to nose ring	6.52″
" " " ring to head locking ring	32.05″
" of cylindrical section	31.1″
" " after and tail sections	45.0″
" " tail cone	5.7″
" " " frame	1.75″
" " after face of tail frame to after edge of horizontal rudder	7.63″
Extreme length	129.75″
Diameter	14.2″

The shell is made from a hard rolled metal, the composition of which shows 80.39 per cent. copper, 19.68 per cent. zinc, and 0.1 per cent. lead. It is one-sixteenth of an inch in thickness.

WEIGHTS.

Practice head complete	130.25	pounds.
Cylinder	236.25	"
After and tail sections	125.75	"
Buoyancy	8.87	"
Total displacement	501.12	"

Hence coefficient of fineness of head	0.723
" " " " " after body	0.535
" " " " " whole torpedo	0.700

Total weight of war head	143.12	pounds.
" " " wet and dry gun-cotton	95.92	"

This gives a charge of gun-cotton equal to 19.1 per cent. of the total weight of the loaded torpedo. Specifications call for 17½ per cent.

AREA OF FINS AND RUDDERS.

Horizontal fins	42.5	square inches.
Vertical fins	42.8	" "
" rudders (each 10 sq. in.)	20.0	" "
Horizontal rudder	27.0	" "

GENERAL DESCRIPTION.

Curve of profile of the Howell.—A spindle of revolution represents the general profile, in which the head approaches a spheroid, the after and tail sections being a perfect spindle, the middle section a cylinder. The profile of the head is a curve of three radii, respectively 260.2,″ 41.″ and 11.8″, beginning at the forward end of the cylindrical section, or head locking rings.

The radius of curvature of the after and tail sections is 227.57″.

The shell is divided into four sections, namely, the head, middle or cylindrical, the after, and tail sections.

For convenience in mounting and dismounting, the detachable sections are the head, cylindrical, and the after and tail sections in one.

The head is dismounted by taking out the set screw in the bayonet-joint, then unlocking it. The after body, by removing the inclined screws in the locking rings. The shafts automatically detach in this section.

The Nose and False Point.—The former carries the firing pin and its mechanism, the latter the firing pin with its safety nut and additional weight equal to that of the firing pin mechanism. The nose with firing pin complete is used in connection with the war head; the false point with the practice head. The nose screws into a nose ring against a rubber gasket on the front end of the head.

The Head (1, Fig. 1).*—The war head contains the gun-cotton and detonator. The exercise head contains an equivalent in weight to that of the gun-cotton charge, consisting of a tank filled with fresh water; a filling hole closed with a screw cap is located in the after bulkhead. The tank is held in place by a cross brace which is screwed to the centering ring. The connection between the head and cylindrical section is made by a bayonet-joint lock secured in place by a set screw.

The Cylindrical Section (2, Fig. 1).—Contains the pockets for depth register, phosphide of calcium, also the fly-wheel, miter gears and driving shafts in which the motive power is generated for driving the propellers, working the impulse movement and pitch mechanism.

The connection with the after section is made by flange-joint rings locked with inclined screws. This locking ring carries a rubber gasket in a groove which effectually closes the joint.

* The figures referred to in the text will be found at the end of the article.

The After Section (3, Fig. 1).—Contains the immersion regulator, the impulse movement, its immobilizer and line sections of shafts. It is connected to the tail section by flange-joint rings locked with a set screw, then brazed solid around the joint.

The Tail Section (4, Fig 1).—Contains the stuffing-boxes for thrust bearings of propellers, their shafts and sleeves, also the tiller rod bulkhead. The rear end of this section is brazed to a tail ring, into which is screwed the tail cone. The latter contains the pitch mechanism and carries the tail frame, fins, rudders and propellers.

THE NOSE (Fig. 2).

As this portion of the torpedo contains the firing pin and its mechanism, which performs the most important work in the final act of the torpedo's run at the instant of contact with the object which it is necessary to destroy, it is therefore most essential that it should be compact and absolutely perfect.

It should be a safeguard against premature discharge in handling, and render it impossible to explode the charge before entering the water. It should be quickly attached at the last moment, previous to inserting the torpedo in the tube. It must be safe in manipulation and readily show without close inspection when in the active and inactive state. It must be effective whether striking the object perpendicularly to its surface or at an angle of 18° with the plane of contact.

The nose consists of a hollow bronze casting (183) which is connected to the head by a single screw joint with rubber gasket (198), and requires but a few seconds to attach or detach it. A steel pin (188) travels in guides (191) in the front end of the nose casting. A thread (185) is turned on the outer end of this pin, on which travels a safety nut (187) with propeller blades. The tip of the pin is capped with a pointer (186), which likewise acts as a guard to the propeller after it has traveled the length of its thread.

A spiral spring (189) on the firing pin seats on the safety cap (184) which is screwed in the outer end of the nose. The inner end of the spiral works on a flange turned on the nipple end of the firing pin. A sear (194) is attached to the cap which acts as in cocking when the pin is set for firing. When prepared for action the safety nut is screwed against the cap, and a soft metal stop pin (190) inserted in the firing pin through the hole in the cap. In this position the spiral spring on the firing pin is compressed and has sufficient force to explode the detonator.

The pin is now inoperative. Upon impact with the water, the safety nut travels out on the pin to the guard and there continues to revolve freely. The pin is now operative. Upon contact with an object, the stop pin is sheared, and the force of the blow, together with the spiral spring, insures its action. The length of firing pin projecting beyond the nose shows whether it is cocked or not.

It is to be remarked, however, that this firing pin does not automatically lock itself at the end of the run of torpedo.

Small holes inclining strongly backward in the nose (183) admit water at the end of the run into the hollow nose chamber, which dissolves the wafers (195*a*) in the primer case cover (65) and drowns the dry gun-cotton and detonator (196), thus rendering a loaded torpedo innocuous.

THE HEAD.

Each torpedo has two heads, viz. the Practice and War Heads.

The practice head (Fig. 1, elevation) is attached to the torpedo when stored in racks.

In the practice head a central tube (7) passes through the water tank (6) and carries lead balance weights which are notched and slide on a feather in giving longitudinal trim to the torpedo. The false point (5) screwed down against the forward bulkhead on a gasket forms a water-tight joint.

The war head (Fig. 1, plan) carries a thin brass cylinder having a diameter equal to that of its centering ring, and is soldered into the shell head and supported by said ring. After the wet gun-cotton is placed, the charge head is soldered into the rear end of the brass cylinder. The charge head has a water hole and cap for correcting the density of the gun-cotton, and is supported by a charge brace.

The primer pocket (64, Fig. 2) contains the dry gun-cotton. It is closed at its after end, and has a flange at its forward end soldered to the nose ring (63). It holds the primer case which carries the percussion detonator (196) at its forward end.

CYLINDRICAL OR MAIN SECTION.

The depth register is held in place by a ring screwed into a socket against a flange, and a rubber gasket on the right side of the cylinder in the plane of the axis of fly-wheel. The depth register is supported by a light bracket soldered in the cylinder. The phosphide of calcium pocket is water-tight and located on top of the cylinder forward of the fly-wheel. In practice a can of phosphide of calcium is inserted

for sighting the torpedo after its run. In war service this pocket is closed by a cork plug, and a water-tight cap is screwed into the depth register socket. This section is stiffened by a strengthening ring. The guide trunnions are mounted on this section with their after ends near the center of gravity of torpedo and above the horizontal plane of the axis of the fly-wheel. In the wheel frame (Fig. 1, *a*) are mounted the fly-wheel (209), its gears (212) with their shafts and couplings, the roller bearings (216) for axis of fly-wheel, and ball bearings (217) for end thrust. The fly-wheel shaft (211) carries a clutch (218) on the starboard end which locks with a double intermediate clutch (219) in a stuffing-box (223); the outer end of this clutch (221) connects with the motor clutch on the launching tube when spinning up the fly-wheel. Oil holes, closed by oil plugs, lead to oil pipes for the different bearings. Immediately abaft the wheel is a light brass screen attached to the wheel frame to prevent the throwing of oil and water by the former on the regulator.

The locking joint between the after end of the cylindrical section and the forward end of the after section is effectually closed by a rubber ring in a groove drawn against the ring faces of the joint by the inclined screws.

AFTER SECTION (3, Fig. 1).

This section carries the support ring, in which is mounted the immersion regulator, which consists of a pressure piston and its spring, the horizontal and vertical pendulums, the immobilizer and impulse mechanism, and the connections to the propeller shafts and tail. Two hand holes (43*a*) are located on top of this section which are closed by covers screwed down on rubber gaskets into sockets, and give access to the immersion regulator for adjustments, inspection, and oiling. On the port, or left, side of the torpedo (see plan view), in the support ring, is cast a flange socket which carries the pressure piston (43*b*). On the starboard, or right, side, opposite the pressure piston, access is had to the regulating screw of the pressure piston spring by removing the cap (43*e*).

The tail section is united to this section by joint rings (45), as described, and carries the tiller-rod supports and propeller shaft hangers (50). The tiller rods (48) and immobilizing rod (49) pass through small stuffing-boxes (47) in the tail bulkhead (46).

The immobilizing rod has a longitudinal motion given by the pitch frame to which its after end is connected. This motion is pro-

portionate to the revolutions of the propeller shafts after launching, and produces a certain effect upon the H. R. (horizontal rudder) pendulum which actuates the H. R. pallet and, through the impulse mechanism, the horizontal rudder. It holds the pendulum forward a short interval of time (from 0.5 second to 3½ seconds after launching, depending upon the tendency of the torpedo to dive), and by means of the cam buffer (49*a*), the lever (49*b*), and the link (49*c*), produces an up-rudder effect. The propeller shaft sleeves (51), secured to the tail bulkhead and soldered to the shell, are prolongations of the stuffing-boxes (52) which are easily reached from the outside of shell. From the tail bulkhead forward to the head locking rings is one compartment.

THE TAIL.

The tail cone (53) is a hollow truncated cone frame, to which are secured casing plates shaped to the cone. These form openings for reaching the pitch mechanism gear, the immobilizing rod, and V. R. (vertical rudder) tiller adjustments, also the bulkhead stuffing-boxes. The cone is secured to the tail bulkhead and is not water-tight.

The tail frame (55) is secured to the tail cone by a tail bolt and supports the horizontal fins (59) and horizontal rudder (60), the vertical fins (56) and vertical rudders (57).

The horizontal rudder frame (58) is screwed to the tail bolt and its ends are connected with the horizontal fins by vertical shoes.

The tail frame also forms bearings for the propeller shafts and carries phosphor-bronze collars between their stuffing-boxes (52) and the frame to define the shafts' longitudinal position. The thrust is taken from the forward collars by the stuffing-boxes.

The casing plates which enclose the propeller shafts are dismountable, likewise the intercostal fins between the tail frame and stuffing-boxes, also the cylindrical covers forward of the propellers (61). These form flush surfaces which act as water guides to the propellers.

To the tail frame are screwed the propeller tips (62); these act as a steady bearing for the ends of the shafts.

A rudder stop (62*a*) limits the upthrow of the rudder on impact with the water in launching and prevents any shock being conveyed to the H. R. pallet.

IMMERSION REGULATOR (Figs. 3, 4, 5).

The support ring (Fig. 3, 89), in which is mounted the regular piston chamber as already described, supports the H. R. pendulum frame (106) on a knife-edge pivot (113) in a bracket at the top of the ring; also the immersion spring (95), the impulse movement (119, 120, 128 and 130), and the V. R. pendulum (117), located on the port side of the torpedo, swinging on its pivot (115).

The principal feature in the immersion regulator is the angle guide (131*a*, Fig. 4) which transmits to the impulse movement (124, Fig. 5) the direction and angular throw to be given to the horizontal (diving) rudder (60, Fig. 1) through the H. R. tiller rod (127, Fig. 5). The angle guide (131*a*, Fig. 4) forms a part of the collar which controls its angular motion in its bearings (149*a*), when actuated by the H. R. pendulum or pressure piston (138*a*). The angle guide has two light flat guide springs parallel to each other and separated about 0.08 of an inch by a projecting pin on its side. The pallet (128, Fig. 5) is mounted on its pivot in the extension (127) of the H. R. tiller rod. These guide springs are separated by the width of the lug face on the end of the angle guide (131*a*, Fig. 4) and admit of divergence from the riveted ends on the angle guide, as they easily bend outward.

The piston rod (146*a*) carries a guide lug (151*a*) which works in the cam slot in the collar of the angle guide; hence when the piston rod moves out or in by the action of pressure on the piston face (139*a*), the collar will turn, also the angle guide, as its support bearings prevent it from taking up a longitudinal motion with the rod.

The piston rod is free to turn in the inner piston face and on its adjustable bearings (145*a*). The angle guide is connected with the H. R. pendulum by the adjustable lever (149*a*) and a pin.

When the H. R. pendulum oscillates, the angle guide lever turns the angle guide and cam collar, and with it the piston rod, owing to the guide lug in the cam slot. Therefore the piston and rod move in and out under varying pressure, turning the angle guide, the cam collar, and, by means of the guide lug in the cam slot, the piston rod. The piston is free to rotate the angle guide, and the H. R. pendulum to rotate both angle guide and piston rod without material resistance from the pendulum and piston working one against the other. The pendulum dominates the piston in the angular throw of the angle guide, which controls the H. R. pallet, and alone causes it to engage five teeth of the impulse rack. The piston alone engages three teeth.

The relative angular effect is adjusted by the travel of piston, angle of cam slot, and throw of the pendulum in arc, and the leverage of pendulum to angle guide. Hence whatever angle is given to the angle guide by the combined action of pendulum and piston, acting conjointly or independently, the H. R. pallet (128, Fig. 5) takes the same angle when the tiller rod in which it is mounted returns to its normal position by the action of the H. R. return springs (133) after an impulse produced by the reciprocating racks (124) on the pallet (128) (also as in Fig. 9). The flat springs (*s*, Fig. 8) of the angle guide acting on the pin *p* of the pallet, guide it to its new angular position to engage the teeth of the impulse racks (124, Fig. 5).

The angle guide springs are so light that the angle guide is always free to take whatever new position the combined action of piston and pendulum may produce upon it, while the pallet and its tiller rod are being pushed forward or aft by the impulse racks. The pallet pin (*p*, Fig. 8) always slides between the springs *s*, the one in contact with the pallet pin *p* yielding easily when the angle changes; and, when the pallet is free to return to normal (parallel to its tiller rod), this spring throws the pin *p* instantly against the opposite spring without subsequent vibration, thus leaving the pallet to engage the impulse racks for such effect on the rudder as the angle guide may define.

THE IMPULSE MOVEMENT (Figs. 3 and 5).

This consists of a frame (122) bolted to the support ring (89). The two impulse racks (124) slide in the frame with reciprocal movement, alternately approaching each other and receding by the action of the cam (120), operated by the worm and gear 119.* A stud on the arm (125) of the after rack, and a stud (126) on the forward rack work in the elliptical groove in the cam, one-half of a revolution of which gives one complete impulse to the racks outward and inward. Thus one complete revolution of the cam gives two complete reciprocating impulses of the racks, causing them to approach each other at the lesser diameter of the groove and separate at the greater diameter.

This reciprocating motion of the racks obviates the loss of an impulse; for one end of the pallet (*p*, Fig. 9), being engaged by the rack *A* and carried forward, acts on the tiller rod, thus drawing the

*In the new impulse a worm and gear on each shaft, immediately abaft the impulse frame, are connected by a transverse eccentric shaft on which two eccentrics connected by rods to the racks give reciprocal impulse.

tiller t forward to t^1 and giving up-rudder action R^1. In the meantime the angle guide changes its angular position sufficiently to tip the pallet when free of the impulse rack A into the position p^2 so as to engage six teeth of the rack F at the next impulse, and, carried aft, acts on the tiller again, thus pushing the tiller t aft to t^2 and giving down-rudder action R^2.

The H. R. tiller rod (127, Fig. 5) and V. R. tiller rod (129) with their pallets and the racks (124) are held in the frame by the caps (123). The tiller rods are always brought back to exact normal position after each impulse by the return springs (133 and 134), aided by the intensity of water pressure on the rudder surface.

In the model of 1892 the return springs are flat and vertical and fastened to the forward end of impulse frame.

When the racks are in the normal outward position, as in Fig. 5, the torpedo level, and the pressure piston normal (midway of travel), the H. R. pallet (128) is underneath and in the opening in the tiller rod extension frame parallel to the latter, and just clearing the racks.

If the torpedo is diving or rising below or above its set depth so as to affect the H. R. pendulum and piston, separately or conjointly, the action of the angle guide will be such as to cause one end of the pallet to engage one or more teeth of the impulse racks as they draw together, depending on the angle of dive or rise, as the case may be. The effect, or angular throw of rudder, is therefore graded according to the number of teeth engaged by the pallet in the racks regulated by the demand made upon the angle guide by the H. R. pendulum and piston.

The number of impulses are 4.5 per second at 8000 revolutions of shafts. The operation of the immersion regulator for controlling the torpedo at a given set depth is as follows: the immersion spring (95, Fig. 3) is set up by means of the regulating screw (102) for a tension equal to the pressure exerted on the effective piston area (90) (mounted in its chamber) by the column of water corresponding to said depth, and through the lever (97) working on its knife-edge pivot (96) holds the piston at its outward position until the hydrostatic pressure equals the spring tension; thus the piston in equilibrium is normal and midway of travel. If then the H. R. pendulum is at its vertical normal position (torpedo axis horizontal), the angle guide is adjusted to hold the H. R. pallet horizontal, the horizontal rudder likewise stands at level, and the torpedo runs at set depth.

The torpedo being *above set depth*, the pressure on the piston being less than the spring tension, the piston will be out as at p^2 (Fig. 10), and the piston rod stud s will be at the point s^2 in the slot in cam collar G; this will tip the angle guide so as to make the pallet p engage the impulse rack with the forward end of the pallet as at p^2, and produce a certain amount of down-rudder, causing the torpedo to dive (R^2, Fig. 9). The pendulum then swings forward and the effect is such that, at a given angle of the pendulum to the torpedo axis, the angle guide is turned by the pendulum, the former tipping the after end of the pallet up in the position p^1 (Fig. 9) so as to engage the after impulse rack A and produce a certain amount of up-rudder in the direction R^1, thereby checking the torpedo's dive and limiting said dive to any desired angle for which the angle guide may be adjusted.

Therefore the turning effect of the pendulum on the angle guide is greater than that of the piston rod's longitudinal movement through its guide stud s acting in the cam slot of the collar G of the angle guide (Fig. 10).

When *below set depth* and approaching it, the reverse action takes place, the same principle controlling the angle of rise. These angles are with reference to the torpedo axis as a horizontal. The pendulum buffer springs (108, Fig. 5) act to delay the swing of the pendulum more or less and adjust said angles at will, the effect of pendulum angles to torpedo axis, however, remaining constant.

The pendulum action on the angle guide through the lever *ol* (Fig. 7) is complete when the pendulum touches either fixed buffer m' or m'' (or as in Fig. 5), and the stronger the spring (108) the more it resists the swing of the pendulum, therefore the more the torpedo axis must tip before the pendulum is opposed by rigid resistance at the buffer.

When the torpedo is below set depth and diving (or point down), the combined turning effect of pendulum and piston is exerted upon the angle guide to tip the after end of pallet p (Fig. 9) to position p^1 to engage the rack A for full up-rudder effect R^1. The total turning effect (8 teeth, pendulum $=5$ teeth $+$ piston $=3$ teeth) is not relatively transmitted to the pallet by the angle guide, as the impulse racks only have a depth for six teeth. Hence the light angle guide springs s (Fig. 8), acting on the pallet pin p, are yielding and thus absorb the extra angular motion of the angle guide, which is equal to three teeth. With the torpedo above set depth and point up, a similar

result occurs and like absorption of a portion of angle guide effect. The H. R. tension springs *s* (Fig. 9), mounted in a sleeve forming a part of the tiller rod near the rudder, are adjusted to regulate the amount of force transmitted from the impulse racks to the horizontal rudder at the different angles of its throw, and absorb the shock of an otherwise rigid impulse action.

VERTICAL RUDDER ACTION.

In order to steer the torpedo on an even keel and insure its rectilinear direction in a horizontal plane, the support ring (89, Fig. 3) carries a transverse swinging pendulum called the V. R. pendulum (117) which actuates an adjustable V. R. angle guide (132) to control the angle of the V. R. pallet (130, Figs. 3 and 5) in reference to the upper impulse racks. When the torpedo rolls by virtue of an exterior force acting upon the gyroscopic force of the fly-wheel, as in launching from a broadside under way or from other causes, the V. R. pendulum (117) swings, under control of its buffer springs, thereby turns its angle guide (132), tips its pallet (130) to engage its impulse racks and transmits to its vertical rudders (57, Fig. 1) a throw proportional to the angle of roll, and in the direction to produce impulses of the vertical rudders acting oppositely to the original on the gyroscopic force, so as to *roll the torpedo back* to an even keel; then the angle guide holds the pallet parallel to and clear of its impulse rack.

The V. R. pendulum pivots on two adjustable central points in the axis of its fulcrum, and is controlled by buffers and springs. Two light angle guide springs also control the V. R. pallet action, by an adjustable angle guide lever to V. R. pendulum frame.

HORIZONTAL RUDDER PENDULUM (Fig. 5).

The frame (106) holds the bob (107) by suspension springs (110). The weight of the pendulum is 9.5 pounds. Its swing is limited by fixed buffers (109) and regulated by the spring buffers (108). The bob is guided and steadied by guide rollers (114, Fig. 3). The suspension springs absorb all shocks of the pendulum upon its knife-edge support.

PRESSURE PISTON (Fig. 4).

The travel of the piston is limited by check nuts (137*a*), on the outer end of rod. The piston proper (138*a*) is cup-shaped. The

flange ring (136*a*) seats on a rubber ring (142*a*) in a groove in the pocket flange of the support ring.

The rubber diaphragm (139*a*) is secured to the piston by a metal washer and set nut (143*a*); its outer rim is secured on the flange ring by a washer and set ring (135*a*), which makes a water-tight joint. The adjustments of piston rod (146*a*) are made by the lock nut (144*a*), the adjusting nuts (145*a*), and socket screw (138*a*).

EFFECTIVE IMPULSE ACTION.

The angular value of the pallet for one tooth of the impulse rack = 2° 17′ 30″. Full stroke of piston, three teeth, = 6° 52′ 30″. Half swing of pendulum, five teeth, = 11° 27′ 30″. This is the motion of the pendulum for 1° swing each way from normal. The longitudinal motion of the tiller rod for one tooth = 0.07″; for six teeth the longitudinal motion = 0.42″, as actuated by the impulse racks. The motion of the racks is 0.5″, thus allowing .08″ clearance for the pallet to take up its new position. The rudder is usually connected by the tiller rod so that each tooth of the impulse rack gives 3° angular throw of rudder. This can be varied by adjustment to 4° or 2° 30″.

The tension of the tiller rod springs can be varied to suit the tendency of individual torpedoes to run above and below set depth.

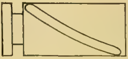
PITCH MECHANISM (Fig. 6).

The pitch mechanism is intended to automatically equalize the speed of the torpedo while the speed of revolutions decreases. With a given number of revolutions of propellers the blades are set at a given pitch. The ratio of revolutions of fly-wheel to those of propellers is as 5 to 4.

If, while the speed of revolution of the propellers decreases, the blades are turned to a higher pitch proportionate to this decrease, the original speed of the torpedo may be approximately maintained.

The principal parts are the trigger (80) in a support (81), mounted on the port horizontal fin; the trigger (80) is held forward by the spring (82) on its shank, an arm of which carries a stud which works in a socket in the worm (78) and prevents the latter from turning with the propeller shafts when spinning up. The inner end of the trigger shank is eccentric and works in a square-faced collar in a groove in the worm clutch (79), which slides on a feather on the propeller shaft, turning with the latter and having a longitudinal motion.

The worm (78), in action, operates the worm gear (76), the pinion (77), the intermediate gear (74), its pinion (75), the cam gear (72) on which is mounted the revolving cam (72*a*), the pitch frame (83) with a stud working in the cam groove (72*a*) giving a longitudinal motion by means of the pitch forks (83*a*) to the sliding cams (85), by working in annular grooves on the forward end of these cams, which slide on feathers on the propeller shafts and have three flat sides,

thus  each with a cam groove, thus 

in which travels a stud attached to the blade lever (86) of the blade (87). Each blade is threaded at its base and screws into the propeller hub and is free to turn about its axis according as the blade lever is moved by the sliding cam groove. When the torpedo is prepared for a run, the cam gear is set at such a point of its revolution that the stud in the pitch frame, working in its groove, has drawn the frame and sliding cams forward, thereby turning the propeller blades to the required initial pitch marked on the rim of the cam gear, and referred to the index finger (88). As the torpedo enters the water, the trigger is thrown back by impact, and catches under a small spring on the trigger support. The eccentric shank causes the worm clutch to move forward, engaging the worm and making it revolve with the shaft. The gears then take up their motion and the pitch frame moves slowly aft, pushing the revolving sliding cams towards the propellers, thereby turning the blades by the action of the blade levers to a higher pitch as the speed of revolutions of the shafts decreases.

The ratio of gearing to shaft is intended to be such that the cam gear will make one revolution while the torpedo is traveling its service range of 400 yards in the present type.

In the model of 1892 the cam curve slotted in the upper face of the revolving cam throws in towards its center. Its construction is such as to give an easy curve for the travel of the pitch frame stud when the cam gear is at its greatest speed, as at the beginning of the run.

The effort of the developed blade areas so nearly coincides with their revolving planes that the work on the sliding cams is very small.

The blades are formed to nearly the maximum pitch for which they are to be used, as a variable pitch blade.

To adjust the cam gear before launching, the screw pivot (77) and worm gear are removed, and the cam gear (72) turned to the desired pitch; the gear and pivot are replaced and the trigger (80) set forward to engage the worm.

In order to overcome the effect of inertia in the H. R. pendulum in launching, and eliminate this error from the proper functioning of the immersion regulator, a cam buffer or immobilizer (49*a*, Fig. 1), operated by the immobilizing rod (49) attached to the pitch frame, holds the pendulum forward against its buffer for an interval of time controlled by the revolving cam, giving longitudinal movement aft to the pitch frame. The latter not only performs this function, but also regulates with absolute certainty the amount of increase and ratio of variable pitch of the blades to the decrease in the number of revolutions per minute, and thereby outlines a limit of blade area whose frictional surface does not necessarily absorb the developed energy of the fly-wheel without a proportional increase in the speed of the torpedo.

With the blades set at an initial pitch of 5.5 inches and the revolutions of propellers 8000, the average slip is found to be about 23 per cent. The diameter of propellers is 6 inches; the helicoidal area of each blade is 3.16 square inches, and the number of blades in each propeller three.

DETAILS OF FACTORY TRIALS AND FINAL ASSEMBLING.

The first trial consists in spinning up the fly-wheel, assembled in the wheel frame with bevels attached for the driving shafts, to a maximum speed of 10,000 revolutions per minute. The wheel is then maintained at this speed for 10 minutes consecutively, when it is allowed to run down, the average time of running down being 69 minutes. Great care is exercised in practically reducing the friction in roller bearing boxes on the fly-wheel shaft, and end thrust ball bearing cases, so as not to diminish the time of running down to less than 65 minutes. The weight of the fly-wheel is 131.5 pounds. It is carefully balanced on its driving shaft previous to assembling, and all eccentricity removed. This test of its physical characteristics necessitates a very high elastic limit and a wide margin between it and the

ultimate strength in order to guard against any liability of deformation. The minimum elastic limit of the steel used in the fly-wheels is 48,000 pounds per square inch. The specific gravity of the steel is 7.85. At a speed of rotation of 12,000 revolutions per minute, the fly-wheel will have reached the minimum elastic limit.

The fly-wheel in its frame is now assembled in the cylindrical section, to which it is firmly attached by screws, and by brazing the flange faces of the fly-wheel frame to the inner face of the shell. The double intermediate clutch in its stuffing-box forms the connection through the shell between the motor and the shaft clutch. It has longitudinal play in its stuffing-box, and the shaft clutch throws it off when the motor clutch is detached, thereby reducing the friction on the fly-wheel.

The trunnion guides are mounted on the outside of the shell and are six inches in length with after ends in the transverse plane of the center of gravity of the torpedo, and 1.5 inches above the horizontal plane. They are riveted through to inner plates and soldered to the shell and form the radial bearings which take the weight of the torpedo when loaded in the launching tube. The strengthening and locking rings having been adjusted, this section is placed in the trial launching tube and a second test made at 10,000 revolutions, in order to insure final success when the torpedo is wholly assembled. Oil holes, closed by screw plugs on rubber gaskets, lead to oil pipes connected with the different bearings in the fly-wheel frame.

The immersion regulator, impulse mechanism, and speed regulator then follow. The immersion regulator and impulse mechanism, mounted in its support ring, is placed in a skeleton frame in the position occupied in the shell. The tail section, wholly assembled and attached to the tail cone, the latter carrying the speed regulator or pitch mechanism, with tail frame, fins and rudders, is also placed in the skeleton frame in the relative position occupied in the torpedo. The fly-wheel is mounted in this frame in its position. The frame is free to revolve in the vertical plane about the axis of the fly-wheel. The shafts for driving the propellers are then connected and lined up and propeller hubs placed. The motor in position, adjusted to the fly-wheel, stands on its own base. It is thrown into or out of action with the fly-wheel by the clutch already described. In the immersion tests the pressure piston is connected with a column of water, which is carried in a 3-inch pipe by means of a hose and cup screwed over the face of the piston. This pressure can be varied at will for any

depth to a height representing 25 feet of salt water. In the immersion regulator tests the pressure is usually set at 10 feet. The skeleton frame is carefully leveled, which represents the longitudinal axis of the torpedo *in the horizontal plane.*

The fly-wheel, impulse mechanism, shafts, and speed regulator are now run at a moderate speed of 4000 or 5000 revolutions until all parts become smoothly adjusted in their bearings without undue friction.

The fly-wheel is then spun up to 10,000 revolutions for a period of ten minutes.

The speed is then reduced to 6000 revolutions and the pressure piston spring set up until its tension equalizes the water pressure; this represents the torpedo at set depth, consequently pressure piston midway of travel.

The H. R. pallet is now free of the impulse racks and diving rudder horizontal.

The next step is to practically determine the *free dive* and *free rise* angles. These indicate the angles at which the torpedo may dive and rise without action of the H. R., the latter remaining normal in the plane of the longitudinal axis of the torpedo.

For example, we will assume the free rise angle to be 1° 15′, and free dive angle to be 1° 00′.

The column of water is then increased to 12 feet, which represents the torpedo *below* set depth and *piston in.* Under these conditions, the torpedo being *level,* the action of the pressure piston is such as to tip the angle guide and cause the rear end of the H. R. pallet to engage three teeth of the impulse racks which push it forward, thereby giving 9° of *up-rudder* (Figs. 10 and 9).

It must be remembered that the skeleton or test frame represents the *after body* of the torpedo, or that portion included between the fly-wheel and H. R.

Hence, if the test frame is lowered, it represents the torpedo *as rising*, or *point up*; if raised, *as diving*, or *point down* (Fig. 10*a*). The test frame is now lowered, which brings the axis of the torpedo point up 1° 15′, the H. R. pendulum swings aft, and the rear buffer spring is set up until the pendulum tips the angle guide so as to bring the H. R. pallet to its normal position, *i. e.*, horizontal to the axis of torpedo and clear of impulse rack; hence no rudder angle.

Consequently the pendulum action neutralizes the piston action, and this constitutes the *free rise angle sought* with the *rising buffer spring* practically adjusted.

The column of water is now decreased to eight feet. Torpedo *above set depth* and *piston out.* The test frame is again leveled and the action of the pressure piston tips the angle guide so as to cause the *forward end* of the H. R. pallet to engage three teeth of the impulse racks, which push it aft, thereby giving 9° of *down-rudder* (Figs. 10 and 9). The test frame is now raised until the axis of the torpedo is 1° *point down.* The H. R. pendulum swings forward and the forward buffer spring is set up until the pendulum tips the angle guide so as to bring the H. R. pallet to its normal position again, which gives no rudder angle. Hence again the pendulum action neutralizes the piston action, which is the *free dive angle sought* and the *diving buffer spring* also adjusted.

By weighing these springs their value in ounces is readily determined. This, however, is not done until the following data have been observed.

IMMERSION REGULATOR TESTS.

Torpedo No. 7. Date, October 15th, 1892.

Compression, tiller rod springs: diving = 32.50 pounds; rising, 32.50 pounds.

H. R. pendulum buffer springs: diving = ⅞ ounce; rising = 1½ ounces.

Position of Piston.	Angle of Torpedo.	Teeth Engaged.	Angle of H. R.	Remarks.
Midway of travel, or set depth.	1° 40′ D	5 A	15° U	
	1° 00′ D	3 A	9° U	
	30′ D	1 A	3° U	
	Level.	0	0	Travel of piston 0″.13.
	37′ U	1 F	3° D	Pressure salt water = 10 ft.
	1° 15′ U	3 F	9° D	Sensitive to change of pressure in 8″.
	2° 00′ U	5 F	15° D	1 tooth = 3° H. R.
In, or below set depth.	2° 00′ U	2 F	6° D	Forward pallet = Down H. R.
	1° 15′ U	0	0	After " = Up "
	37′ U	2 A	6° U	
	Level.	3 A	9° U	
	30′ D	4 A	12° U	
	1° 00′ D	6 A	18° U	
	1° 40′ D	6 A	18° U	
Out, or above set depth.	1° 40′ D	2 A	6° U	
	1° 00′ D	0	0	
	30′ D	2 F	6° D	
	Level.	3 F	9° D	
	37′ U	4 F	12° D	
	1° 15′ U	6 F	18° D	
	2° 00′ U	6 F	18° D	

H. R. pendulum forward engages after pallet.
H. R. pendulum aft engages forward pallet.
Speed at tests, 6000 revolutions.
Full dive angle, 1° 40′.
Full rise angle, 2° 00′.
Free angle of dive, 1° 00′.
Free angle of rise, 1° 15′.

The above tests having been found satisfactory, the skeleton frame is dismounted. The support ring is soldered in place in the after section of the shell, also the hand hole plate and locking rings. The after and tail sections are then connected and the joint finally brazed.

The torpedo now being wholly assembled and lined up, the longitudinal eccentricity of the axis is determined, and if greater than 0.02″ it is corrected by the inclined screws connecting the cylindrical and after sections. It is then passed through the gauge, 14.20″ in diameter.

The final spinning up in the launching tube is now made at 10,000 revolutions for a period of 10 minutes. This insures the practical working of the fly-wheel, shafts, propellers, impulse and pitch mechanisms.

TANK TESTS.

1. The balancing test is made in a tank of salt water 20 x 2½ x 3 feet deep. Straight edges placed across the tank with sliding perpendicular scales over the locking rings at each end of the cylindrical section indicate when the torpedo is floating horizontally. This condition is insured by moving the lead weights in the tube located in the fresh water tank in the head.

2. The center of buoyancy is determined by forcing the torpedo down with a horizontal straight edge, transversely placed on the cylindrical section, until wholly submerged.

3. The buoyancy is determined by adding small lead washers on a cord until the torpedo sinks horizontally. This cord encircles the shell in the transverse plane of its center of buoyancy. The cord and lead weights are removed and weighed in the water, which gives the buoyancy in pounds.

4. The center of gravity in air is then determined by balancing the torpedo on a knife edge.

5. The practice head is removed and its center of gravity determined in order to define the center of gravity of the loaded war

head. The head is again attached and the torpedo relined on a template.

6. The total displacement is determined by weighing the torpedo and adding surplus buoyancy.

The following table will show the results of tank tests:

Center of gravity of practice head forward of head locking ring	17.15″
Center of gravity of war head forward of head locking ring	17.10″
Center of gravity of torpedo, with practice head, abaft head locking ring	19.40″
Center of buoyancy wholly submerged abaft head locking ring	15.80″

Total weight with practice head	492.25	pounds.
Surplus buoyancy	8.87	"
Total displacement	501.12	"

The test for leakage is made on the trial grounds by sinking the torpedo to a depth of 15 feet for a period of five minutes. This is done with light safety lines attached at each end of torpedo and lead weights fastened around the shell.

This finishes the factory tests and brings the torpedo up to the point where it is ready for trial runs.

SERVICE ADJUSTMENTS.

The most essential feature in practice is a proper adjustment of the several functions of the immersion regulator.

It therefore becomes necessary for each torpedo officer to make himself familiar with the principle, in detail, upon which is based the individual action of the immersion regulator of each type of torpedo under his charge. This involves a practical study of the several adjustments and the methods in use to verify them. It also demands his personal verification of all practical adjustments in each torpedo, and the most careful analysis of any irregular action during practice runs and trials. Observe the vessel of the future in which the practice trials and runs of automobiles are rigidly executed in conformity to the Torpedo Manual which will be issued by the Bureau of Ordnance, and you will there find the successful torpedo officer. I unhesitatingly say successful, because of the fact that each and every

instruction laid down for his guidance is based upon practice under all conditions in which the automobile could be exercised. Furthermore, in order to execute these instructions he must be thoroughly acquainted with its practical requirements. Hence the individual labor that must be expended to attain that degree of proficiency which will insure the successful handling of the automobile in the near future.

INITIAL DIVE.

The initial dive and its duration from impact to return to set depth is dependent upon three conditions:—

1. Upon having H. R. tension springs of high initial and maximum tension. In practice the test results give initial, 32 pounds; maximum, 55 pounds. With an initial dive having a velocity of 50 feet per second, and with a H. R. area of 27 square inches, the rudder having a maximum throw of 18°, the intensity of pressure exerted on the rudder is $AKV^2 \sin^2 \theta$, in which:

A=area of rudder=27 square inches.

K=0.019782 pressure on 1 square inch of rudder surface.

V=29.5 knots.

θ=18° maximum rudder angle.

Then $27 \times 0.019782 \times \overline{29.56}^2 \times \sin^2 18° = 44.56$ pounds, which comes within the margin prescribed.

2. Upon immobilizing the action of the H. R. pendulum, *i. e.* setting it against the forward buffer as in *point down*, and making duration of contact with the immobilizer from 0.5 to 3.5 seconds, depending upon the action of the torpedo to dive after impact, as shown on the depth register card.

3. Upon maximum rudder angle, the area of the rudder remaining constant. Take the first case to illustrate. (See Fig. 10*b*.)

No. 1 curve is typical of the best possible form in the action of the immobilizer to control the torpedo. Set for 10 feet, the initial dive is less than 15 feet, or less than 1½ times the set depth. In four seconds of time, or at 68 yards, the torpedo has returned to set depth and within the limit of its full rise angle of 2°.

The maximum rudder angle is sufficient, also the initial and maximum tension of the H. R. tiller rod springs as shown in the curve of rise wherein the first vertical rise above set depth should be less than three feet under favorable circumstances, viz. a smooth sea.

The second vertical dive below set depth is less still, and the

second vertical rise likewise diminishing. The torpedo then runs its range with a less variation than 18 inches above or below the set depth.

No. 2 curve shows the action of the torpedo without immobilization of the H. R. The result is a sudden initial dive. It also represents the want of sufficient maximum rudder angle by the extreme depth reached, and length of time in returning to set depth.

No. 3 curve is the result of too much of an interval of immobilization, and weak H. R. tension springs, as the torpedo comes to the surface immediately after impact with but slight initial dive, and runs on the surface by virtue of its buoyancy, and the power of the H. R. being absorbed in the weak tension.

No. 4 curve represents too long an interval of action of immobilizer, and not sufficient maximum rudder angle.

LONGITUDINAL ECCENTRICITY.

Place the torpedo on a template and line up, using the two locking rings at each end of the cylindrical section for a base of reference, and the margin of nose ring and tail cone to determine respectively in the four quadrants the head and tail eccentricity. There will, however, never be any appreciable head eccentricity, as the locking rings of these two sections are squared up after final assembling in the shell. The lining up should be done with the greatest possible care, as any mistake in the determination of eccentricity in the horizontal plane becomes a constant angle of deviation in that plane.

VERIFICATION OF IMPULSES AND RUDDER ANGLES.

Level the torpedo carefully. This work may be done on board ship, in port, by placing the torpedo fore and aft in the vertical plane of the keel and leveling up. Take off hand hole plates and throw out the action of the immobilizer. Attach the H. R. angle gauge to rudder frame. Then revolve the fly-wheel with the hand crank clutch, at the same time elevate and depress the head, i. e., *point up* and *point down*, noting the angular throw of rudder for each angle of inclination of axis, as in the immersion tests; the impulse cam also, to make one revolution for each angle of inclination, commencing with its major axis parallel to that of the torpedo as the origin.

SPEED REGULATOR.

Note the position of the revolving pitch cam and observe that it is always set for the initial pitch, marked on its pitch circle, which will

give the speed at 10,000 revolutions of fly-wheel. In order to change the pitch, remove the first follower from the meshes of the worm on the shaft, then turn with the fingers the revolving pitch cam to higher or lower pitch required, then replace and screw down the first follower.

Also test the action of the pitch trigger and its collar, by throwing it into and out of action with the worm collar.

IMMOBILIZER.

Set the immobilizer for interval of contact with H. R. pendulum, as given in the record accompanying each torpedo, or as may have been found most advantageous in practice with the Howell. Replace hand hole plates.

LEAKAGE.

Lower the torpedo over the side into the water. Receive it alongside one of the ship's boats. Attach cod lines 15 feet in length to nose and tail frame. Sink the torpedo 10 feet by lead weights on a cord encircling the shell in transverse plane of center of buoyancy. If air bubbles rise to the surface their position defines the place of leakage.

Note the buoyancy and lines of flotation, then hoist the torpedo on board.

When ready to load in the launching tube, screw in the depth register and place the phosphide of calcium in its pocket, both ends of can punctured. Finally lubricate the outside of shell and trunnion guides.

IMPORTANT FEATURES OF THE HOWELL.

In defining the important features of the Howell in the general classification of the automobile torpedo, one must consider the number of requirements it is called upon to fulfill.

1°—*Concentration in size relative to diameter and length with great strength of shell and rigidity to resist deformation with least possible weight.* The total weight of shell, strengthening and locking rings, is less than 20 per cent. of the loaded torpedo, while the weight of explosive charge is more than 19 per cent.

2°—*Its effective working range as compared with its total weight, being greater than that of any other type with equal displacement.*

3°—*Its capacity to maintain a comparatively uniform speed by virtue of its speed regulator;* the automatic action of its pitch mechanism, being governed by the ratio of decrease of revolutions of the fly-wheel, thereby increases the pitch of the blades correspondingly, which reaches a maximum at the end of its effective working range.

It has also been found that, by compounding the motive power in the present system, the speed is increased over 50 per cent. and the effective working range doubled. Also that similar conditions are obtained with the cylindrical fly-wheel type of increased weight, the maximum capacity of which has not yet been fully determined for a torpedo of 18 inches diameter.

4°—*Capacity to maintain a rectilinear direction in the horizontal plane.* The gyroscopic force of the Howell gives great rigidity against horizontal deflection of the longitudinal axis in a yielding medium within a range of 800 or 1200 yards of the target, when subjected to sudden shocks, as upon impact in launching, or opposing surface currents, which are met with on soundings, and at approaches to all harbors more or less. In the part of this article under which I propose to discuss the question of the Dynamical Effect of Broadside Launching it will be observed that the only effect of the sudden shock due to impact in the keel angle of fire, with vessel at speed, is to slightly roll the Howell on its longitudinal axis with a sudden motion, having only the fraction of a second of duration.

This action places the Howell in a new gyroscopic plane at a fixed angle with the original until the motion of the vertical pendulum, which swings transversely immediately when its horizontal plane is disturbed, brings into full action the impulses of the vertical rudders.

These impulses become repeated shocks applied in the opposite direction to the original and continue until the vertical pendulum is again horizontal, likewise the torpedo.

It will be readily seen that the action of rolling gives to one of the components of force in the diving rudder a horizontal steering power.

In practice it is found in keel angle of fire, at speed of vessel, that the automatic action of the vertical rudders to right the torpedo is so rapid and effective as to counteract the horizontal force imparted to the diving rudders by rolling; therefore horizontal deviation due to rolling motion is practically eliminated within the effective range. Besides, the rotating forces of the twin screws of the Howell

mounted on parallel shafts act in opposite directions in their revolving planes, and consequently balance themselves, to all practical purposes. Hence there is no necessity for readjustment of vertical rudders for any change in the speed of the vessel, or keel angle of fire, after loading the torpedo in the tube and waiting for the object to come within its effective range.

5°—*Capacity to maintain a set depth at any speed within its maximum range.* As the motive force of the Howell is stored in the fly-wheel during its flight, its weight is always constant, and therefore does not decrease, like other types of automobiles ; consequently unlike them it is not subject to the same disturbing forces induced by loss of weight which changes the position of center of gravity and center of buoyancy.

These variations produce errors more or less in a horizontal rectilinear direction, or constancy of depth.

The Howell, however, maintains a comparatively uniform depth at any speed throughout its maximum range.

6°—*Sensibility of the immersion regulator to control the torpedo at a set depth.* The degree of sensibility of the immersion regulator to control the torpedo at any depth is increased when the friction of the hydrostatic piston is reduced to a minimum. It therefore approaches the acme of perfection when reduced to the frictional bearing of the pressure piston only ; this to become constant under any movement of pendulum or piston in opening the pathway to a motive power which in turn actuates the horizontal rudder. The angle guide and pallet turn without appreciable effort as they are nicely balanced on their pivots, and with the light pressure piston rod produce the only friction or work in the motion performed by the piston and pendulum in defining the angle of the guide at each instant.

This holds good whether the combined effects of the pendulum and piston are in conjunction or opposition, or otherwise acting independently, one of the other, in transmitting the angle which is given to the angle guide.

The angular throw of the horizontal rudder varies directly with its pallet and becomes a series of elastic impulses per second, in which the intensity of its effective force is governed by the angle transmitted through the angle guide and its pallet to the impulse rack.

DYNAMICAL EFFECT OF BROADSIDE LAUNCHING WITH VESSEL AT SPEED.

In reviewing the practice with the automobile by foreign countries it is found that no attempt has been made to determine a practical solution of the dynamics of broadside launching with the vessel at speed. All efforts in this direction, however, have failed to produce any reliable data whereby efficiency has been increased beyond bow and stern launching.

It is very evident that there must be some recognized law upon which the dynamics of broadside launching should be founded. From the nature of the automobile the dynamical effect of disturbing forces becomes apparent at initial dive and influences the accuracy of its flight to a greater or less extent. Under these conditions it follows that there must be developed in the automobile a controlling force which will produce rigidity in the longitudinal axis against angular deviation in the horizontal plane. These conditions are fulfilled in the Howell by the directive force generated in the plane of the longitudinal axis through the gyroscopic motion of the fly-wheel. Under these conditions the dynamical effect at initial dive is brought within the range of experimental determination.

Having witnessed several hundred shots with the remodeled Howell under all conditions of weather and temperature, in which I kept a complete record of all adjustments for each run, and results produced in the torpedoes as affecting immersion and accuracy of direction in the horizontal plane, I was led to make a series of experiments in order to determine the *dynamical effect* of broadside launching and the method to be adopted to counteract it.

The apparatus employed consisted of one of the fly-wheels assembled in its wheel frame with bevel gears and driving shafts attached. The wheel frame was mounted in a ring (1, Fig. 11) so as to revolve freely in the vertical plane of the axis of the wheel (Fig. 13). This ring was mounted on a standard (2) having a circular base (3) free to revolve in a horizontal plane about the center of gravity of the fly-wheel. Both ring and standard revolved in ball bearing cases so as to reduce the friction of the whole mount to a minimum. A lever (4, Fig. 11) attached to the standard ring and representing the after body of the torpedo, in its longitudinal axis, was also free to revolve in the horizontal plane. A series of blows was applied to this lever at a distance of 5.3 feet from the center of gravity of fly-wheel at a point

which represents the position of the vertical rudders on the torpedo. The number of blows for each series was ten; they were also of equal force for each series, instantaneous, and at equal intervals of time, and made to represent the shock produced on impact at initial dive.

A steam motor, mounted on a separate standard which was stationary, connected with the axis of the fly-wheel by the usual clutch, and admitted of being attached and detached at will.

The action was as follows: With the motor attached to the fly-wheel, the latter was spun up to the number of revolutions desired, and the motor then detached, the ring and standard released, thus leaving the wheel free to revolve in the vertical plane of its axis, and the standard in the horizontal plane. Successive blows were then applied horizontally, at right angles to the lever, and their force measured by a pressure gauge. The result produced upon the fly-wheel was a rolling motion about the longitudinal axis of the torpedo.

Further, when the force (P, Fig. 12) was applied on the starboard side of the tail (4), the torpedo rolled to starboard (R, Fig. 13). When applied on the port side of the lever (P_1, Fig. 12), the torpedo rolled to port (R_1, Fig. 13).

Starting with 2500 revolutions, it was found that ten successive blows, each having a force of 2 pounds, rolled the torpedo 10.25°, or an average of 1° 1′ 30″ roll for each blow.

With 4500 revolutions it required a force of 4 pounds to roll the torpedo 1°.

At 6500 revolutions 6 pounds produced a roll of 1°.

At 8500 revolutions, for 1° roll, the force of the blow was 8 pounds, and at 10,500 revolutions, for 1° roll, 10 pounds.

Hence the force varies with the revolutions in an arithmetical progression.

Determination of the Intensity of Directive Force for an Average of 1° Roll of Torpedo. July 12, 13, 1891.

Lieut. F. J. DRAKE, *Observer.*

Revolutions	2500		4500		6500		8500		10500	
Force......	2 Pounds.		4 Pounds.		6 Pounds.		8 Pounds.		10 Pounds.	
	DEGREES OF ROLL.									
Number of successive blows.	Star-board.	Port.	Star-board.	Port.	Star-board.	Port.	Star-board.	Port.	Star-board.	Port.
1	1°.25	1°.	1°.	1°.	0°.75	1°.	1°.	1°.	1°.	1°.
2	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
3	1.	1.	1.	1.	1.25	1.	1.	1.	1.	1.
4	0.75	1.	1.	1.	1.	1.	1.	0.75	1.	0.75
5	1.	0.75	1.	1.	1.	0.75	1.	1.25	1.	1.
6	1.	1.25	1.25	1.	1.	1.	1.	1.	1.	1.25
7	0.75	1.25	1.	1.	1.25	1.25	1.	1.	1.	1.
8	1.25	1.	1.25	1.	0.75	1.	1.	1.	0.75	1.
9	1.	1.	0.75	1.	1.	1.	1.	1.	1.	1.25
10	1.25	1.	1.	1.	1.	1.25	1.	1.	1.25	0.75
Sum........	10°.25	10°.25	10°.25	10°.	10°.	10°.25	10°.	10°.	10°.	10°.
Mean.......	1°.025	1°.025	1°.025	1°.	1°.	1°.025	1°.	1°.	1°.	1°.

Force applied on *port* side of head, the torpedo rolls to *starboard.*
Force applied on *starboard* side of head, the torpedo rolls to *port.*

Demonstration.

The intensity of normal pressure due to direct head resistance at right angle to the course of the vessel at a speed of 20 knots is $\frac{20\times 6080}{60\times 60}=33.777$ feet per second; and $\frac{(33.777)^2}{64.333}=17.73$ feet=height due to a velocity of 33.777.

Then 17.73×64.125 pounds$=1137$ pounds per square foot.

The launching velocity of the torpedo is 41 feet per second.

Time of immersion from tip of nose to center of gravity of torpedo is $\frac{4.34}{41}=0.1059$ second.

The longitudinal sectional area of the torpedo forward of its center of gravity is 4.52 square feet.

The center of effort of this sectional area is 1.98 feet forward of the center of gravity of the torpedo.

The resistance of the convex surface of the torpedo whose sectional area is 4.52 square feet is $\frac{1}{2.3}=0.4348$ of its sectional area.

The resistance of the longitudinal sectional area is $1137 \times 4.52 \times 0.1059 = 544$ pounds; and the resistance on the convex surface is $544 \times 0.4348 = 236.6$ pounds, or $236\ 6 \times 1.98 = 468.3$ foot-pounds, exerted at the center of gravity of torpedo.

By table "A," at 10,000 revolutions of fly-wheel, 9.5 pounds $\times$ 5.3 feet, the distance of the center of gravity of the torpedo from the force applied, $=50.4$ foot-pounds, required to roll the torpedo $1°$.

Then at 20 knots speed of vessel the torpedo will roll $\frac{468.3}{50.4} = 9°\ 18'$, and for speeds under 20 knots, as follows:

At 19 knots $= 8°\ 45'$.	At 10 knots $= 3°\ 48'$.
" 18 " $= 8°\ 12'$.	" 9 " $= 3°\ 15'$.
" 17 " $= 7°\ 39'$.	" 8 " $= 2°\ 42'$.
" 16 " $= 7°\ 06'$.	" 7 " $= 2°\ 09'$.
" 15 " $= 6°\ 33'$.	" 6 " $= 1°\ 36'$.
" 14 " $= 6°\ 00'$.	" 5 " $= 1°\ 03'$.
" 13 " $= 5°\ 27'$.	" 4 " $= 30'$.
" 12 " $= 4°\ 54'$.	" 3 " $= 00'$.
" 11 " $= 4°\ 21'$.	

This is the dynamical effect of broadside launching at right angles to the course of vessel.

At an angle with the course the resistance is found to vary with the $\sin^2$ of the keel angle of fire.

Take for example the Philadelphia, which is to be equipped with the Howell broadside tube.

Extreme train forward, 60°.

The resistance is $468.3 \times \sin^2 30° = 117$ foot-pounds. Hence, $\frac{117}{50.4} = 2°\ 19'$ roll of torpedo at 20 knots speed.

The after tubes have an extreme train aft of 17°.

The resistance is $468.3 \times \sin^2 73° = 428.3$ foot-pounds; and $\frac{428.3}{50.4} = 8°\ 30'$ maximum roll at 20 knots speed.

As the torpedo always rolls towards the stern in the vertical plane of fire, the tendency will be to deviate horizontally in range forward of the line of fire. In order to overcome this lateral deviation, I considered the maximum resistance under the following conditions:

First. Moment of resistance of vertical rudder surface per square inch.

The effect of pressure, due to the velocity of the torpedo in the water, upon the vertical rudders acting under impulses, and which forms a couple with resultant force in the longitudinal axis of the torpedo, is to roll it about its axis towards the side on which the rudders act.

The normal intensity of pressure is resolved into two components, viz.: (1) a longitudinal component, $KV^2 \sin^2 \theta$, which is the direct head resistance offered by the rudders when at an angle $\theta = 18°$ with the middle line of the torpedo; (2) $KV^2 \sin^2 \theta \times l \cos \theta$, which gives it a rolling motion.

In Fig. 14, plan view, consider the moment and resistance of the vertical rudders.

K = resistance on one square inch of rudder surface moving perpendicularly to itself at a speed of 1 knot = 0.019782.

V = 23 knots, velocity of torpedo.

$l = RG$ perpendicular from normal RP to center of gravity G.

7° 7° = vertical rudder.

Then the direct head resistance offered by one square inch of rudder surface is $KV^2 \sin^2 \theta$.

In (2), $l \cos \theta = RG$.

M = rolling moment.

V = 23 knots. l = 5.3 feet.

Substituting the values in (2) and solving, $M = 0.019782 \times 529 \times \sin^2 18° \times 5.3 \cos 18° = 5.037$ foot-pounds per square inch

Second. Area of vertical rudders.

The vertical rudders when in action, due to a transverse rolling motion of the torpedo exceeding 2°, produce their maximum effect.

The area of the V. R. must therefore be considered under the conditions which affect the action of the torpedo in a unit of time.

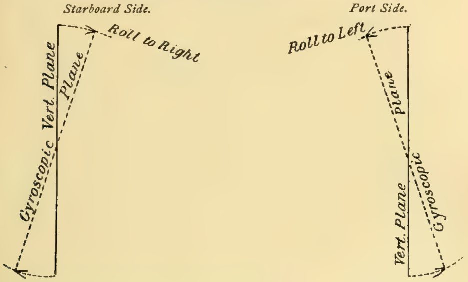
The vertical rudders must also right the torpedo before it shall have covered a distance of 60 feet, or reached its set depth, when launched at a keel angle of 90° with vessel at maximum speed of 20 knots or more.

At this speed the resistance on the convex surface is 468.3 foot-pounds exerted at the center of gravity of the torpedo.

The impulses given to the vertical rudders are 4.5 per second.

Multiplying this by the rolling moment, $M = 5.037$, gives 22.67 foot-pounds for one square inch per second. Hence $\frac{468.3}{22.67} = 20.66$ square inches; which is the area given to the vertical rudders and found to be practically effective.

Therefore the effect produced by the initial dive, under these conditions, is a rolling moment in the Howell and it changes the gyroscopic plane instantly to a given angle with the vertical as determined by the speed of platform, keel angle of fire, and revolutions of fly-wheel, as shown in the accompanying sketch.



Rectilinear direction in the Whitehead is maintained by means of vertical rudders adjusted, previous to discharge, for speed of vessel and keel angle of fire, and which maintain a constant angle throughout the flight of the torpedo.

The impulse movement in the Howell is such that, for a roll of more than 2°, the vertical rudders give the full throw, and for less than 2° roll the following: viz.,

1° 40′	roll of torpedo	15° angular throw of V. R.
1° 20′	" "	12° " " "
1° 00′	" "	9° " " "
40′	" "	6° " " "
20′	" "	3° " " "

Thus with powerful impulses the gyroscopic plane of the torpedo is brought rapidly back towards the vertical until the angular distance between the two is less than 2°, when a continually decreasing impulsive force is exerted until the two planes coincide.

The vertical rudders, being controlled by a vertical pendulum acting in connection with the impulse mechanism, are automatic and act only when the torpedo rotates about its longitudinal axis.

Consequently they require no adjustment for speed or keel angle of fire.

In stationary firing the torpedo will very seldom rotate on its longitudinal axis within its effective range.

It will be possible with the present Howell speed regulator, to give it a speed equal to that of the Whitehead of same caliber, as the pitch mechanism can be adjusted so as to absorb the maximum energy of the fly-wheel in developing speed.

In order to insure the same percentage of directive force and rigidity against rolling in the Whitehead, Schwartzkopf and Hall torpedoes, and thereby increase their efficiency in broadside launching with vessel at speed, the following has been recommended to the Bureau of Ordnance:

To place a fifty pound fly-wheel in each of the above named types of torpedo adopted in our service, independent of its present mechanism. This fly-wheel to be connected with the necessary impulse movement, vertical pendulum, and vertical rudders.

This is to be done by increasing the displacement in the cylindrical section by additional length.

This combination could be launched from a Hotchkiss tube specially constructed, after spinning up the fly-wheel to 8000 or 10,000 revolutions, with the compressed air still acting as motive power for driving the propellers.

This would bring the several types of automobiles into close competition for determining relative efficiency as broadside weapons possessing a maximum capacity for speed, range, immersion, rectilinear direction in the horizontal plane, and rending force.

AUTOMOBILE TORPEDOES IN BROADSIDE LAUNCHING AT SPEED.

A period of seventeen years marks the practical use of the automobile torpedo as a recognized weapon to be used in war.

England, France, Germany and Russia have experimented with the automobile as developed in the Whitehead and Schwartzkopf types with the object of establishing some degree of efficiency in broadside launching.

ABOVE WATER DISCHARGE.

In above water discharge, spoons have been added to the muzzle of the launching tubes extending beyond the side of the vessel sufficiently to give the torpedo a comparatively free drop horizontally. This has been found necessary in order to limit the angle of dive which, in a measure, affects the initial dive.

Besides, automobiles of the Whitehead type, being particularly sensitive to any outward force which disturbs the horizontal equilibrium at the instant of impact, are given as low a velocity of discharge as will insure a free clearance of the tube and spoon.

It is also necessary that the speed of the vessel and the keel angle of fire remain constant for any one discharge, as the vertical rudders are set to fulfill these conditions previous to the launching.

Therefore, any change of speed or course in the heat of action always necessitates readjustment of the vertical rudders, which complicates the efficiency of broadside launching and might possibly result in failure to reach the enemy.

The true automobile torpedo must therefore, of necessity, be of such a type that any change of speed, of platform, or pivoting of launching tube in order to bring the enemy in line of fire, will not retard its action nor affect its accuracy in flight. It must automatically adjust itself to these conditions, and thereby leave the torpedo crew to give their entire attention to keeping the object in range until the instant of launching.

Approaching the enemy, the commander is then prepared to give his vessel the greatest possible speed upon entering the dangerous zone, and use such tactics in manœuvering as may develop the best means of coming within striking distance.

To what extent a loaded torpedo is protected when subject to the rapid fire of B. L. R. and machine guns, depends upon the type of shield employed to protect the muzzle of the tube and the attached war head. One shot safely landed in the nose or upon the detonator would cause the absolute destruction of the torpedo vessel.

Therefore it becomes necessary in above water discharge to protect the tube and torpedo with an oblong shield spherical in shape and of proper thickness to insure the perfect action of the torpedo up to the instant of launching. At the point opposite the muzzle of the launching tube there should be a port buckler in the shape of a revolving elbow nicely balanced, and worked by a powerful lever so

as to drop downward, the action of the elbow to precede that of the firing.

Adjacent launching tubes are to be used so that an attack made upon a vessel at anchor with her torpedo net down will result in launching consecutively two or more torpedoes concentrated upon the same point of attack, and within 2½ or 3 seconds of each other. The launching tubes must be capable of such adjustment as will conform to a maximum speed of vessel at an effective range up to 800 yards at least.

The present launching tube is virtually unprotected against rapid fire.

As it is necessary to protect modern guns with fighting shields in order that their service may be effective, so it is equally necessary to protect the launching tubes of the automobiles and their machinery under similar conditions, if corresponding efficiency is to be developed within their range.

Furthermore, loaded torpedoes cannot be moved about deck in action, hence each launching tube must be loaded previous to an engagement, and therefore absolutely requires a safe protection. The light shields now supposed to be in use are far from fulfilling the object intended. Hence, modern developments point to the need of a permanent protection for launching tubes, by adopting fighting shields of greater weight, and consequently torpedo boats of increased displacement.

UNDER WATER DISCHARGE.

In bow fire the torpedo well is filled and the vessel carries dead water in the channel pipe which extends from the outer skin of the vessel to the muzzle of the tube. Thus, in launching, before the nose of the torpedo is fairly projected from the under water body, the propellers are turning in water, and accelerated speed is produced which, in the motion of translation, enables the torpedo to clear the hull, and almost at the required set depth. Absolute certainty must be given to this discharge, otherwise the commander labors under the fear of never knowing when he may overrun a loaded torpedo, which result might prove disastrous.

A perfect system of electric signals should extend from every launching tube to the fighting towers, which would automatically indicate upon the face of electric dials the instant of discharge as well as the instant the torpedo is clear of the ship's side. This is a matter

easily arranged and always effective in its action. The same system may be employed to discharge a torpedo at the will of the commander, by throwing into action the electric discharge circuit. In broadside launching it is found that the English and French have experimented with every conceivable type, and would have adopted a permanent system had 25 per cent. of their results been successful.

Determined efforts, however, to retain broadside launching virtually eliminated the question of a variable speed, thereby placing a handicap upon the manœuvering qualities of the vessel using the Whitehead type, for the essential feature of self-contained directive power in the type of torpedoes used was found wanting. Consequently, this led to a complication of mechanism in the launching apparatus which assumed such proportions as to become unwieldy and unreliable with a vessel at maximum speed. Hence, in all manœuvers conducted abroad as object lessons, we hear very little relative to the launching of automobile torpedoes from the large cruisers at speed in forcing an attack. This is confined to torpedo boats of light displacement and above water discharge, while armored cruisers and battle-ships acting on the defensive show their alertness in detecting the presence of these torpedo boats, which, if discovered within the dangerous zone, have but a single chance of escaping complete annihilation.

It has also been demonstrated that a vessel going at a speed of 12 knots, with a moderate sea and swell of only 3 or 4 feet from crest to hollow of wave, is comparatively safe from an attack.

This is due to the irregular action produced upon the automobile in its initial dive by sea and swell from an above-water discharge. For, in the drop from muzzle of launching tube, should the torpedo strike the crest of a wave it is almost certain to broach and be deflected by its imperfect submersion at impact.

Besides, the torpedo-boat of low freeboard must move at a speed of at least 16 knots in order to select its position for attack. In so doing, its decks and surface tubes become deluged with water which renders them almost useless. This reduces to a minimum the possibilities of the present low freeboard type of torpedo-boat under 500 tons displacement as effective sea-going craft.

In making an attack they must therefore confine their manœuvers to a smooth sea, a dark night, slow vessels, and these lying at anchor in a harbor without torpedo nets out; for in the event of war, the fast cruisers would be employed at sea and have but little time in port,

and then only for coal, provisions, and such repairs as cannot be made in the fleet under way.

It is evident from a careful study of this subject, and the nature of our coast and harbors and their approaches, that in the beginning we should have a modern torpedo fleet composed of about twenty-five boats of the Cushing type and displacement for the defense of the mouths of our harbors, to act within a radius of 20 miles of their base of supplies. The coast-line should be patroled by 10 torpedo-cruisers of 800 tons displacement and upwards, capable of fighting in a moderate seaway, and self-sustaining for a period of 30 days, with a cruising speed of 12 knots and a maximum of 25 knots, and a radius of action of 9000 miles.

DEGREE OF EFFICIENCY TO BE REACHED WITH THE AUTOMOBILE TORPEDO.

The automobile represents the highest development among naval torpedoes, and is found to possess speed, range, and rending force not to be excelled by any other type of submarine projectile. By virtue of its design it becomes a weapon of offense. In an attack it is opposed by secondary batteries and machine guns. Its ratio of efficiency, therefore, within a fighting range of 800 yards, must compare favorably with that of light ordnance within its range.

In the combination of the automobile, the vessel at speed, the commander in the conning tower, and the torpedo officer at the launching tubes, we have the elements in which the degree of practical efficiency alone can decide the question of an attack. Hence how important it is that in the general service routine every effort should be made by commanding officers of our cruisers equipped with automobiles to carry out rigidly the quarterly exercise with this weapon. Vessels cruising in the vicinity of New York, Boston, Portsmouth, etc., should exercise with automobiles in Gardner's Bay, where extreme ranges can be had and net targets safely anchored. Those cruising south of New York and north of Port Royal to use torpedo grounds in Chesapeake Bay. Those cruising south of Port Royal and in the Gulf to use grounds laid out in the Gulf. These torpedo grounds in home waters for trial runs to be definitely located by the Bureau of Ordnance under the approval of the Secretary of the Navy. Commanding officers of vessels in foreign waters to select and report upon trial grounds wherever they shall be found suitable for the purpose.

The depth of water should be five fathoms at least, with sandy or hard clay bottom; to be as little affected by currents as possible, and laid out with regard to scope for trial runs with the vessel at speed. Then commence trial runs with vessel at anchor, or moored stem and stern so as to lie bow on or broadside to target, as the case may be, with the necessary number of boats out, and such observers as will be specified in the torpedo instructions.

From trials at anchor proceed to trials under steam with vessel comparatively stationary; then to running trials with vessel at speed: making a series of three shots at least from each tube. At first there may be some mishaps and much weariness of spirit; nevertheless this work must be continued, even should it consume one or two weeks of constant attention to complete the series. By these efforts alone shall we be able to reach that degree of efficiency necessary to handle the automobile with success. It will also have its individual effect in fleet tactics wherein battle-ships and armored cruisers moving into position for a night attack, the former accompanied by two or more torpedo cruisers acting directly under the supervision of the commanding officer of the battle-ship, become a unit in which the battle-ship is the base for any and all changes in the tactical evolutions. The torpedo cruisers become scouts for warding off and defeating torpedo attacks which would naturally be made by other torpedo-boats upon the battle-ships.

Should the commander of an armored cruiser or a battle-ship attempt, in the presence of an enemy, to manœuver his vessel with the net out, he at once hampers himself to such an extent that the speed and turning power of his vessel are reduced to less than 50 per cent. He therefore exposes himself to the danger of an attack from a fleet of torpedo-boats which would then take possible chances under the cover of night to place a torpedo regardless of his net defense, the efficiency of which is much reduced by his speed.

One of the most important features, then, in an attack with the automobile is to have some definite means by which the commander may determine the course and speed of the enemy; then will he be able not only to decide his course of action, but the most effective point at which he should enter the dangerous zone.

Three torpedo cruisers of modern construction should advantageously engage an armored cruiser or battle-ship between twilight and early dawn, acting jointly on a preconcerted plan in which three lines of attack should be made simultaneously.

It should be distinctly understood that the essential features of efficiency of the automobile consist in fighting battle-ships and armored cruisers; but the greater the degree of the efficiency of the automobile and the more powerful and impregnable the armored torpedo cruiser which carries it, the more severe are the restrictions it places upon the freedom of action of the battle-ship and armored cruiser when under way. It also lessens their degree of safety when lying at anchor with nets out, and forces unlimited vigilance, which past efficiency of the automobile has not disturbed.

Developments in all types within the last three years will show that it is worse than useless to argue against the future certainty of the automobile to reach a degree of efficiency, within its range, not excelled by any other weapon which is capable of deciding an action with one or two shots.

LINE OF ATTACK.

The safest line of attack which can be made upon a battle-ship or cruiser by two or more armored torpedo vessels, acting conjointly, is that which exposes them to the concentrated fire of the secondary batteries the shortest interval within the dangerous zone; hence the bow and quarter line of attack. As the length of time necessary to handle the heavy guns of the main battery in a seaway is usually more than seven minutes, a greater interval than would be required for the torpedo cruiser to pass through an exposed arc of 135° within the dangerous belt, the probability of a shot from this battery is therefore not considered, owing to the high speed and rapid change of bearing and distance of the torpedo cruiser.

The first evolution of the torpedo cruisers will then consist in taking a beam line of bearing, numbers 1 and 2 on the starboard, and number 3 on his port beam, or *vice versa*, distant not less than five miles.

Second evolution.—Observe his course, note his time, then steam ahead at full speed parallel to the enemy's course until he is brought on a quarter line of bearing distant about 8.5 miles. Then slow down and keep this position until No. 2 torpedo cruiser has taken a bow and quarter line position on Nos. 1 and 3 and ahead of the enemy. (Fig. 15).

Third evolution.—At a given signal from No. 2, Nos. 1 and 3, having observed the enemy's speed, will take a traverse course, such that at full speed they will be brought in contact with the former in the shortest space of time.

No. 2 goes about and steers for the enemy at full speed. If the torpedo cruisers are capable of a 24-knot speed they will arrive within 2000 yards in ten minutes.

In two minutes more they will be within effective range with their torpedoes. Passing astern consecutively on each beam, they will fire first their bow torpedoes, then broadside.

Thus, three attacks can be made in rapid succession and several torpedoes launched, of which one or more should be effective, and this with only six minutes exposure within the dangerous belt. The rapidity of such an onslaught within so brief an interval of time is more than liable to produce a demoralizing effect in the efficient service of secondary batteries.

Any other line of attack necessitates a longer interval of exposure within the effective range, which accordingly diminishes the successful chances of the torpedo cruiser. It will always be found that a successful attack will be combined with a high rate of speed, and consequently a rapid change of position of the attacking party.

No. 2 torpedo-boat, instead of making an attack from directly ahead, could, however, remain astern, and thus cut off the enemy's escape from an engagement by a sudden change of course. By this change in the first evolution, only two of the modern type of torpedo cruisers are brought into action, with the possible launching of six torpedoes by firing both bow tubes consecutively, and then the broadside tube.

Besides, any change of course of the enemy brings him sooner in conflict with No. 2 astern and No. 1, or with No. 2 and No. 3, according as he changes course to port or starboard. On the other hand he may force a single engagement by steaming at full speed for No. 1 or No. 3 on his bow bearing, or No. 2 astern, and thus avoid a simultaneous attack from two or more of the torpedo cruisers. Then it becomes a question of a single torpedo cruiser launching his three torpedoes in the five minutes in which he will be exposed within the dangerous zone.

Under these circumstances the modern armored torpedo cruiser of high speed should be able to withstand effectively the fire of secondary batteries from a battle-ship until within safe striking distance and with chances of winning the fight.

PRESENT EFFICIENCY OF AUTOMOBILE TORPEDOES.

It is claimed by many, laboring under a delusion relative to the principles of the automobile torpedo, that, up to the present, its efficiency is limited to a few spasmodic efforts which do not add to its intrinsic value as a reliable means of under-water attack. It is true that over 98 per cent. of the practical attempts to blow up vessels in war have proved failures. Without stopping to consider this declaration, the casual observer condemns then and there the efficiency of the automobile.

Has it ever occurred to those who assail its efficiency that numerous other conditions surround it? Efficiency in the automobile is not an inherent quality; it is dependent upon a careful and distinct adjustment of all its parts, each to perform its several functions without friction or clashing with its neighbor. Like any delicate piece of machinery constructed of the best material, it must have a skillful and competent director. He must be in harmony with his work and thoroughly acquainted with every detail. As the several bearings, guides, pistons, etc., of an engine are adjusted and lubricated previous to starting, so much more should the several parts of the automobile torpedo. Were it possible to make an investigation and test the accuracy of the adjustments of the torpedoes which have been lost in practice and failed in war service, and of the thoroughness of the system of exercise under the individual torpedo officer, undoubtedly there would be found a want of proficiency in the latter to produce efficiency in the former; and to this cause I should trace nine-tenths of the failures. There is no question that, within its scope, the automobile is efficient when handled intelligently.

The elements of fighting power in the automobile are limited to attacks made upon the under-water body. Hence it becomes necessary to combine in it the highest degree of efficiency in order that it may not be deflected horizontally from its course by any change of its previous condition.

The successful torpedo officer of the future must serve faithfully his apprenticeship to the torpedo by personal contact. He may master the principle of its action in a day, but only long and continued application to the study of every detail of its mechanism will reveal to him its fineness of construction and its delicacy of adjustment. He must see the result of the labor of his own hands in the adjust-

ments made in practice trial runs, and not until then will he begin to comprehend the limit of its sensibility in responding to his manipulation.

The neglect of any one detail in its several adjustments is liable to cause its loss, as it augments an individual eccentricity in the torpedo which destroys the harmony of action in the mechanism.

Following the recent advent of the Howell, it is safe to say that the efficiency of the automobile has been doubled, as it now becomes a weapon capable of automatically correcting the disturbing influences due to a broadside discharge with the vessel at speed. Hence we mark the most important step which has been made in its practical efficiency, and present the torpedo under fighting conditions which, within its range, can be made to equal those of ordnance projectiles.

There is no longer any necessity for slowing down the speed of the vessel in order to discharge an automobile from a bow, stern, central pivot, or broadside tube.

The element of danger which has been found to exist from impact, viz., overrunning the torpedo in bow launching at any speed of vessel, is now entirely overcome, as the Howell is given a launching velocity the rate of which exceeds that of the highest speed attainable in torpedo-boats or cruisers. Neither is there any future necessity for bow launching tubes placed in the plane of the keel and piercing the stem in order to increase their efficiency in a rectilinear direction.

Accuracy of aim in bow fire does not materially affect the result with the tube at an angle of 3° with the line of keel, for the highest efficiency consists in launching at any keel angle of fire regardless of speed of platform.

Granting that the automobile, if properly adjusted, will do its work, then the question of practice follows, in which the officers and men detailed for this service must be trained in an intelligent and practical manner with all of the attendant surroundings in which practice forms the element of efficiency in actual warfare.

To what extent this may be carried will depend upon the individual interest exercised in developing the most effective system of instruction in torpedo practice, and our combined effort to make this arm of the service worthy of the respect and consideration of every commander of a war vessel.

It is not to be inferred from this that a select body of officers and

men should be quartered on shore and go out occasionally in a torpedo-boat when weather permits, to witness two or three shots in a day or an afternoon; neither should it be considered conducive to a proper *esprit de corps* to endeavor to gain a practical knowledge in shore quarters of a weapon purely designed for under-water service afloat. In my opinion there is only one way of reaching this point of efficiency, and that consists in building without further delay at least two sea-going training automobile torpedo-cruisers, each having at least 1500 tons displacement, possessing the highest possible sea speed and greatest possible conveniences for handling and recovering all types of automobiles. In this equipment must be included suitable nets and floats for ranges, and a complete diving outfit for examining the bottom for missing torpedoes. Comfortable quarters for officers and men should be fitted, including a lecture and draughting room, and each ship should have all of the factory appliances for repairing, assembling, adjusting and testing. Order to these vessels such officers and men as will be required in our cruisers to complete their complement in the torpedo outfit.

Select three cruising and practice grounds, one south, in the Gulf for winter work, the second in Chesapeake Bay, and the other north for summer work. These vessels to repair to their stations according to the season; to go to the practice grounds and there remain five days out of the week, engaged in a system of routine exercises in dismounting, assembling, adjusting and firing, with vessel moored, then stationary, and finally at speed. In this practice, projections of the curve of flight to be drawn to natural scale, from which lectures and discussions will be made relative to the result of the adjustments for each individual run. A complete record of this work to be forwarded to the Bureau of Ordnance for future reference in comparing the action of automobiles in general service, and to form the base for future instruction in the post-graduate course at the War College and Torpedo Station for commanding officers and others who hold the interest of a progressive torpedo service paramount to ordinary routine duty.

After three or four months of such active service, each officer under instruction to deliver a theme setting forth his views, impressions and explanation of such improvements in service practice as may be suggestive of points attaining to higher efficiency.

The men under instruction to be subjected to a rigid examination relative to all practical elements. The whole to become a part of the Bureau's record.

After completing this course, the officers and men to be relieved by others and ordered to the different cruisers having automobile torpedoes as a part of their outfit.

We shall then have in service a corps of officers and men educated up to a practical standard of proficiency, who understand thoroughly the usefulness of this weapon, and are capable of developing with it some degree of efficiency worthy of the name. Therefore action should be taken to bring before the Secretary of the Navy the necessity for two such cruisers to be contracted for and built without delay. For the present emergency, equip the Vesuvius and gunboat Machias with a complete outfit of automobile torpedoes and the necessary appliances for repairing, recovering, adjusting, etc., and have them enter upon this duty at once. In the place of the present main battery of the Machias mount broadside tubes. In the case of the Vesuvius mount 3 tubes in each broadside. With these two vessels we have at once the necessary conditions of speed limits from 14 knots up to 20, for a complete broadside practice.

The Cushing and torpedo-boat No. 2 should be connected with this work for the necessary demonstrations in bow launching at different speeds, and other conditions which are more easily exemplified in the smaller type of torpedo vessels. General efficiency in the service will be promoted by such action, and the expense incurred in this temporary outfit, until regular vessels are completed for this special service, will be more than compensated for by the advantages and practical knowledge which will be gained. Further, such action will undoubtedly save to the service the loss of many torpedoes, as well as our reputation for efficiency in the first attempts made to handle new combinations with which all connected are more or less ignorant.

I see no other way out of the groove into which other nations have settled after having introduced automobile torpedoes into their services. If the heads of the departments are slow to act in this matter we must put up with the consequences and console ourselves with the humiliating condition accepted by other countries, namely, possession of one of the most important weapons of warfare without any real knowledge of its possible efficiency.

If we intend to take hold of the automobile torpedo let us do so in a reasonable and intelligent manner, and not stop where we begin. Let us guard against over-confidence in our ability to rise to the emergency when called into action, only to discover our inefficiency when the test comes.

PROBABLE TYPE OF FUTURE TORPEDO CRUISER AND DESTROYER.

Having reviewed somewhat the present development in the automobile torpedo, and the probable efficiency which will be reached in its new departure, there must necessarily follow an equally progressive move in the construction of a modern type of torpedo cruiser (Fig. 16). This vessel must not only possess the qualities of a good sea-going craft, but have a maximum speed of 24 knots. The general dimensions are 300 feet length, 40 feet beam, and 14 feet mean draught; displacement about 2000 tons. The general design of the vessel is upon the longitudinal and bracket system, with an inner bottom extending from the forward collision bulkhead to the stern. The space between outer and inner skins is to be divided by the frames into water-tight compartments.

PROTECTIVE DECK (Fig. 17).

The protective deck will curve downwards at the sides to three feet below the load water line. The flat or crown will be one foot above the load water plane. This deck will have an under plating of one-half inch steel, on which will be worked the protective deck plates. The outside strake of the deck plates is to be five inches in thickness, the next strake inboard to taper in thickness from five to three inches, the third strake to taper in thickness from three to two and one-half inches, the remainder of deck to be two and one-half inches, not including the lower course of plating. All hatches through this deck will have battle plates; the smoke pipes and ventilators will have inclined armor plating of five inches thickness.

CONNING TOWERS (Fig. 16).

The conning towers are to be two in number; one, forward, of 12 inches thickness of steel plates, the after one to be of 10 inches thickness. From these the movements of the vessel will be directed in action. They will be built in the superstructure, elevated sufficiently to give an all-round view, and supported from the protective deck. They will be elliptical in shape, and their greatest dimensions will be eight feet by six feet. An armored tube five inches thick will run from each tower to the armored deck to protect the steering gear, speaking tubes, signal wires, etc. In addition to the armored conning towers there will be a deck house fitted with chart tables, speaking

tubes, steam steering wheels, etc., for use when not in action. All bulkheads below the protective deck are to be water-tight.

The hull above this deck will be of light construction and given to the arrangement of quarters for officers and men and the stowage of provisions. The principal coal bunker capacity will be under the protective deck. Temporary cruising coal bunkers above the protective deck around and over the engines and boiler space will deliver coal by gravity process to the fire rooms through hatches, which will be closed when going into action. A perfect system of artificial ventilation will be supplied for that portion of the hull under the armored deck; communication to be had with all parts by ducts leading to blowers. The vitiated air will be withdrawn by the fans used to force combustion. The explosive gases of the coal bunkers under protective deck will be drawn into the funnel casings, and fresh air pipes lead to the conning towers. The pumping and drainage system will be complete, and every compartment connected with powerful steam and hand pumps.

The ship will be lighted by electricity having duplicate plants. The dynamos will supply power for internal illumination, side lights, head lights, coal bunker lights, and lights in magazines and torpedo compartments. Two powerful search lights will be fitted, for tracing other torpedo vessels, etc., or to aid in the navigation of intricate channels.

The engines and boilers will be below the protective deck. In the arrangement of boilers, longitudinal and transverse bulkheads will be fitted with the best system of forced draught; this will divide the boilers into compartments in pairs, thereby affording greater protection to the machinery and making the boilers less vulnerable to attacks from B. L. R. and machine guns. The engines will be of the triple expansion vertical inverted type, with four cylinders, and capable of developing 9000 horse power, or sufficient to give the speed of 24 knots required. They will be duplicate, each placed in a water-tight compartment, and shafts parallel. There should be 26 water-tight compartments below the protective deck in the division of torpedo rooms, magazines, boilers, coal bunkers and engines.

LAUNCHING TUBES (Fig. 18).

The chief feature of this vessel will be the torpedo armament, which will consist of four under-water 18″ discharge tubes, each placed in a water-tight compartment under the protective deck.

Two bow tubes are parallel to the line of keel, each tube four feet from the middle line and separated transversely by a longitudinal middle line bulkhead; the channel pipes leading to the muzzle of these tubes to have their outer ends square and projecting three inches from the outer skin of hull.

The starboard (forward) broadside tube has a horizontal train through an arc of 75° from 60° forward of the beam. The compartments for these tubes occupy the space forward of the forward boiler-room bulkhead.

The port (after) broadside tube has a horizontal train through an arc of 75°, from 45° forward of the beam to 30° abaft the beam.

TORPEDO MAGAZINES.

The forward magazine is located between the bow tubes and broadside compartment, and is accessible from this compartment through water-tight doors.

The after magazine is immediately abaft the after torpedo compartments and accessible through water-tight doors in bulkheads.

ORDNANCE MAGAZINES.

The magazines for rapid fire and machine guns are located under the protective deck; the ammunition to be served through armored tubes of five inches thickness, extending to the upper deck with the electric hoist, and the magazines to be accessible through water-tight doors in the torpedo magazine passages forward and aft.

TORPEDOES.

The torpedoes will be stowed in racks in each torpedo compartment, and loaded in the tubes by means of a torpedo car running from the racks to loading position of the tubes; the car to run by a gearing and crank, so as to be under the control of one man, regardless of any motion of the vessel.

The appliances necessary in preparing torpedoes for launching are in a separate compartment adjacent to the torpedo rooms, and accessible through water-tight doors. Two plants will be required for this purpose, one for serving forward tubes, the other for after tubes.

A general repair shop for the battery and torpedoes will be located between the forward fire-room bulkhead and after broadside launching-tube bulkhead.

MOUNT FOR LAUNCHING TUBES (Fig. 19).

The broadside tubes will be mounted on training carriages with the muzzle in a ball-and-socket, water-tight joint, trap, and well in the apex of the water channel. The carriages will train by means of worm gear and ratchet. The deck circles are to be graduated, every five degrees to close a circuit which will be recorded on a dial in the conning towers. Circuits for firing and indicating when the torpedo is clear of the hull, are to be fitted also.

BROADSIDE WATER CHANNELS.

The broadside water channels are of peculiar shape. The forward one in a longitudinal sectional view is oblong in shape, about 30 feet in length and 3 feet in vertical width as measured on the outer skin of the under-water body. On this outline a flat wedge with rounded corners is cut out horizontally in the side, the apex ending in a circle of 20″ diameter, and 16 feet inboard from the outer skin measured horizontally in a transverse section of the hull. (Figs. 16, 18, and 19.)

The transverse section of the hull intersects this aperture in the diameter of the 20″ circle, which forms the muzzle of the launching tube with its ball-and-socket joint.

The forward edge of this wedge-shaped water channel is at an angle of 65° horizontally with the transverse section, and admits of launching a torpedo with a train forward of 60° also.

The after edge has an angle of 25° with the transverse section, and allows for 15° abaft the beam as an angle of fire, and the set of the torpedo aft in passing from the water channel which is carrying dead water having the velocity of the ship to the live water outside. (Fig. 19.)

The after channel is also wedge-shaped, the forward edge making an angle of 45° forward of the transverse section which intersects the apex. The after edge is 45° abaft the transverse section, which gives a train of tube for launching from 45° forward of the beam to 30° abaft the beam.

The upper face of the forward water channel is inclined upward 2° from the apex at the muzzle of the tube, to the outer skin. The lower face is inclined downward 5°. In the after water channel the upper face is inclined upward 5°, the lower face downward 5° from the apex to the outer skin.

With the vessel at a maximum speed of 24 knots and the launching velocity of torpedo of 41 feet per second, the set towards the stern will be found to be about five feet in order to clear the ship's side. The torpedo entering the water channel from the muzzle of the launching tube at a speed of 41 feet per second becomes wholly immersed in dead water with its propellers revolving, and acquires an accelerated velocity immediately in passing from this dead water in the channel through the eddy into the live water outside. The water being a yielding medium, the effect produced upon the torpedo is similar to that of an opposing surface in the line of flight, set at an angle equal to the resultant of speed of vessel and torpedo, and acting about the center of gravity of the latter. The ratio of the length of the torpedo to its velocity defines the width of the resultant as an opposing surface, which gives the horizontal deflection parallel to the original line of fire.

Were the muzzle of the tube flush with the outer skin of the under-water body, the moment that the torpedo commenced to leave the tube it would be violently swept aft, and jam the torpedo in the tube unless a guide bar were used as in the Whitehead under-water discharge.

The dead water in the channel pipe, however, having the same velocity as the vessel and a pressure due to the speed, is comparatively still water, and takes the place of the guide bar without its faults.

The torpedo entering this water entirely clears the muzzle of the tube before the nose comes in contact with the live water outside. In addition the torpedo also rolls slightly, which is immediately corrected by the automatic action of the vertical pendulum and rudders, as set forth in the section on the Dynamical Effect of Broadside Launching. These conditions refer only to automobiles having directive force.

A vessel thus equipped has a train for broadside launching through an arc of 75°.

The two bow tubes being parallel with the keel are favorable for any condition of making an attack bows on.

The water channels leading to the muzzles of the launching tubes are four feet below the lower edge of the protective deck and always in still water.

The torpedo is therefore the least affected in launching by any rolling motion of the vessel.

The intercepted frames in the broadside water channels are supported by a network of inside girders longitudinally placed and riveted to the continuous frames at each end of the channel.

Therefore, efficient range of the automobile under the above conditions is not limited to a rigid mount, having only a direct keel line of fire similar to the detachable ram, or submarine gun, or Vesuvius type of aerial projectiles.

Neither does its velocity, directive force and range depend upon its velocity of discharge.

Hence, if efficiency consists in constructing vessels for the purpose of carrying a weapon whose accuracy of aim is wholly dependent upon the skill exercised in *steering the vessel*, how much greater the necessity to construct a type of vessel to carry the automobile which possesses directive, as well as propulsive, force and is capable of any keel angle of fire, regardless of the course and speed of the vessel. Consequently this type of vessel would be able to make an attack in a seaway at speed when it would be impossible to launch a torpedo from a surface tube under any conditions whatever. Also, the efficiency of the vessel as a torpedo platform is greater than that of a cruiser as a gun platform, manœuvering under similar conditions of weather.

The accuracy of flight of the torpedo is affected only by the swell, and the initial dive becomes a minimum, as the torpedo will be launched at least 7 feet under the load water plane and near its set depth.

A vessel of this type would, without doubt, be one of the highest efficiency. The protective deck would be capable of resisting nine-tenths, if not all, of the shots that could possibly strike it from a secondary battery, which otherwise would pierce the hull below the water line.

Her great speed gives great manœuvering capacity, which will stimulate her commander to choose at will the best possible conditions for an attack. In the present development of torpedo-boats the possibility of chances in making a successful attack are very few, in consequence of limited speed in any seaway; besides, the punishment they would now receive from rapid-fire guns, if discovered, means absolute destruction. Hence they must seek the cover of night for any possible protection, with the above-named restrictions added. Whereas the modern torpedo-cruiser as outlined almost reverses the above conditions, and insures success for the automobile

as an offensive weapon which must absolutely be recognized by every commander.

From a careful study of the subject I can see only one other condition under which the automobile torpedo could possibly reach that degree of efficiency which must be obtained in order to compare favorably within its range in offensive action with secondary batteries; viz., to place all the broadside launching tubes upon a disappearing mount for the above-water discharge. Each tube would then be mounted upon a revolving platform *under* the protective deck; a spherical turret cap 4 inches thick revolving with the platform and directly over it would project above the protective deck sufficiently to admit of the rise of the launching tube for discharge. The port in the cap would be shaped to the muzzle of the tube, and would open and close automatically by the action of the mount in rising and disappearing. The sloping barbettes in which the turret caps rest and revolve would be 5 inches in thickness and bolted to the protective deck. The two bow launching tubes would remain as under-water discharge. The barbettes would extend to the sides above the protective deck, and the superstructure be built to them.

In action the superstructure may then be shot away and not interfere with the working of the disappearing mounts or the launching of torpedoes. The loading of the torpedo in the tube should be capable of execution from any point of its train when the mount is down and the tube resting on the platform.

The tube is trained to the desired angle of fire by revolving the platform on which the disappearing mount is located. The mount works independently of the revolving action of its platform; the mechanism being such that the tube may be raised or lowered while the platform is revolving. The whole action of loading a tube, training the platform, and elevating the tube for firing may be done by steam or hand gearing and a crew of six men.

It will be observed that with this arrangement for *above-water* discharge the chances for exploding a loaded torpedo, or destroying the launching butt mount with shots from a secondary battery, are reduced to a minimum.

Only by this, or a similar radical change in the present type of torpedo-boats and torpedo-cruisers, will any practical degree of efficiency ever be reached.

RUNNING TRIALS WITH THE HOWELL.

Figures 20, 21, and 22 are views illustrating the efficiency of an automobile possessing directive force through the gyroscopic motion of its fly-wheel, thereby insuring accuracy in bow and broadside launching with vessel at speed.

These views are copyrighted photographs of the Stiletto at full speed making trial runs with the Howell in Mackerel Cove. They were taken by Mr. Frank H. Child, photographer, No. 242 Thames Street, Newport, R. I., to whom I am indebted for the privilege of publishing these views in the NAVAL INSTITUTE PROCEEDINGS.

The Stiletto is equipped with one bow tube, and one central pivot tube mounted aft on deck having an all-around train.

Fig. 20 represents bow launching at full speed, on range with a net target placed at 400 yards. The record shows: "Set depth 10 feet. Buoyancy, 8 pounds. Velocity of Stiletto, 32 feet per second. Muzzle velocity, 42 feet per second. Initial dive, 13 feet. Struck net at depth of 11 feet. No horizontal deviation. Choppy sea and swell setting in from south. Torpedo came to surface in line of fire at a maximum range of 800 yards."

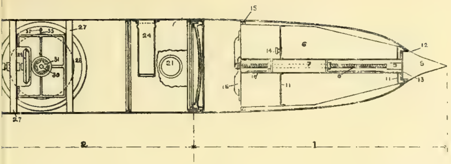
Figs. 21 and 22 represent two views, with an interval of about one-seventh part of a second, of the same discharge from the central pivot tube; keel angle of fire, 90°. These are good illustrations of the torpedo's flight from the muzzle of launching tube to impact, and demonstrate the following conditions, viz.: "Height of axis of launching tube above water, 6′ 7″. With center of gravity of torpedo at 9′ 7″ from muzzle of tube, angle of inclination of torpedo axis below axis of tube, 5°. Drop of torpedo, 1′ 3″. Horizontal distance of center of gravity of torpedo, at impact, from muzzle of launching tube, 19 feet. Inclination of axis of torpedo to horizontal, 16°. Initial dive, 20 feet. Set depth, 10 feet. Velocity of Stiletto, 31 feet per second. Muzzle velocity of discharge, 42 feet per second. Torpedo apparently not deflected, as it came to the surface at the end of its range in the prolongation of its line of fire."

The trials of the Howell torpedoes have been conducted in Mackerel Cove, located at the south end of Conanicut Island at the entrance to the harbor of Newport. This cove is open due south to the full swell of the Atlantic. It is about 1¼ miles in length and ½ mile in width. The middle bottom on the range of trial grounds is of hard sand. The shore line is rocky and steep in

places. The cove shoals gradually from the mouth to its head. Usually a ground swell and sea sets into this cove, which is greatly influenced by weather outside. Hence the majority of trial runs of the Howell have been made in live water under conditions of weather similar to those that will be encountered in actual service.

FIG. 1

ELEVATION



PLAN

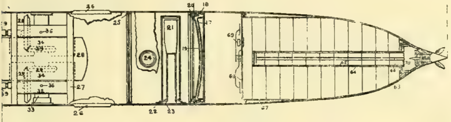
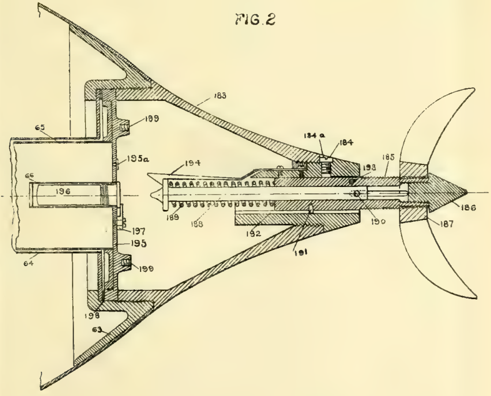


FIG. 2



FIRING PIN

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FIG 1
ELEVATION

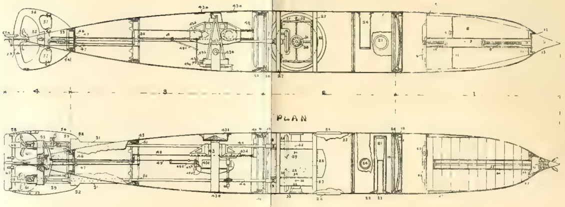
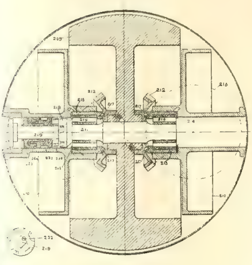
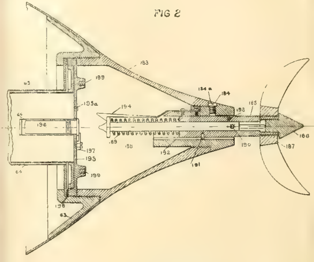


FIG 1ª



FLY WHEEL AND CLUTCH

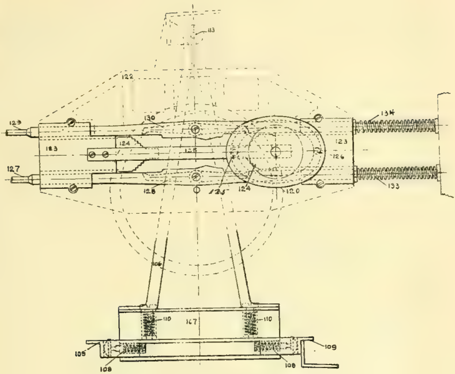
FIG 2



FIRING PIN

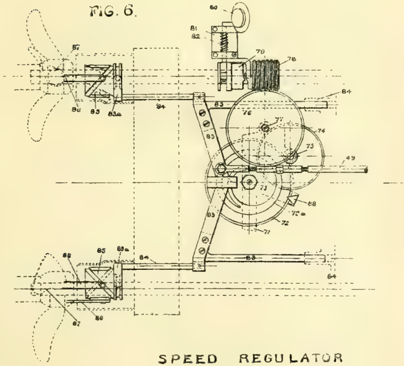
ELEVATION

FIG. 5



IMMERSION REGULATOR

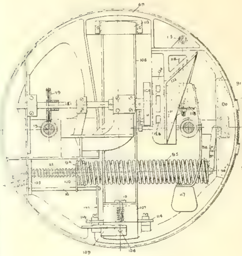
FIG. 6.



SPEED REGULATOR

CROSS SECTION

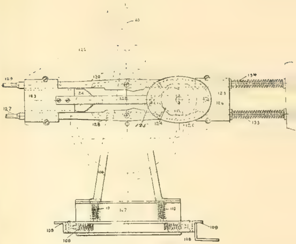
FIG 3



IMMERSION REGULATOR

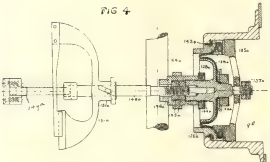
ELEVATION

FIG 5



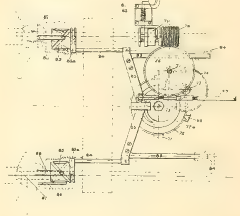
IMMERSION REGULATOR

FIG 4



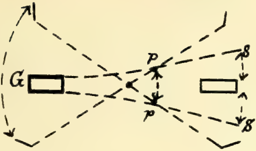
DETAILS OF
.M REG' PISTON
MODEL 1892

FIG. 6

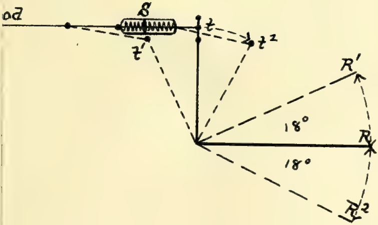


SPEED REGULATOR

Fig. 8.



9.



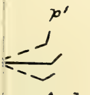


Fig. 7.

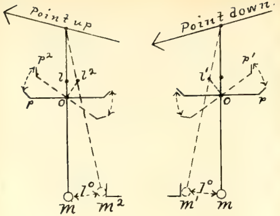


Fig. 8.

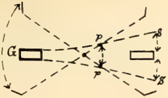


Fig. 9.

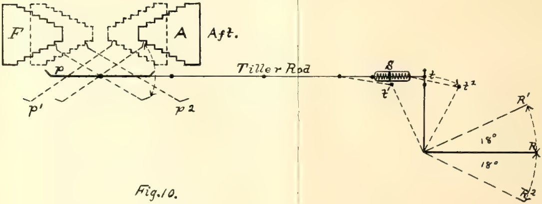
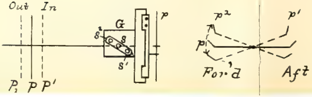


Fig. 10.



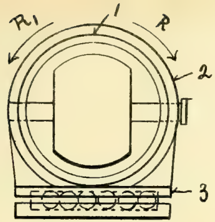


Fig. 13.

Fig. 14

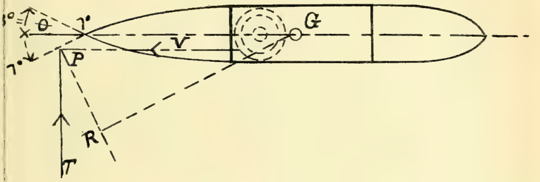


Fig. 15

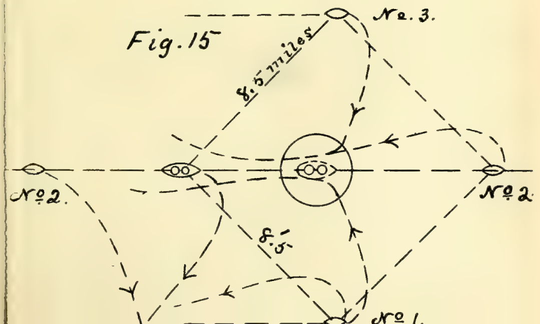
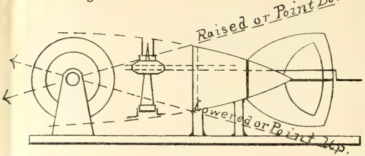


Fig. 10a.



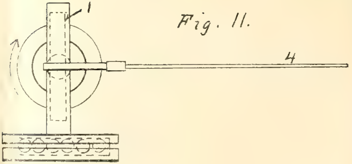


Fig. 11.

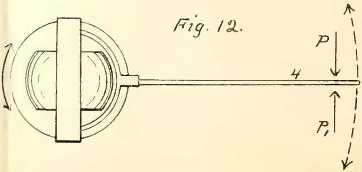


Fig. 12.

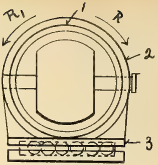
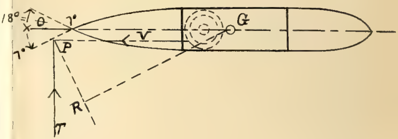


Fig. 13.

Fig. 14



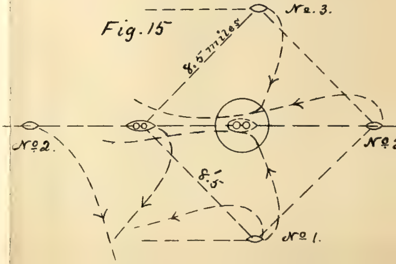
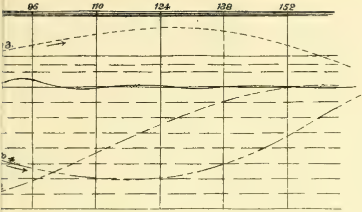


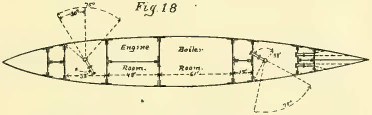
Fig. 15



EPTH CURVES,

mobilizer and Tension Springs.

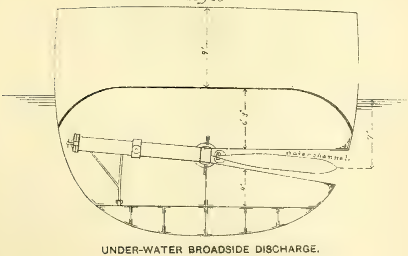
Fig. 18



PLAN VIEW BELOW PROTECTIVE DECK.

Armored Torpedo Cruiser. 2000 Tons Dispt.

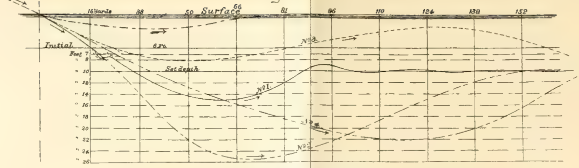
Fig 19



UNDER-WATER BROADSIDE DISCHARGE.

Forward. Frame 76 ft.

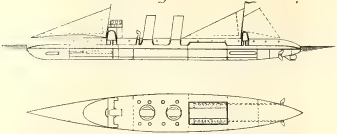
Fig. 10b



AUTOMOBILE DEPTH CURVES,

Under different conditions of Immobilizer and Tension Springs.

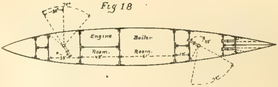
Fig 16



ARMORED TORPEDO CRUISER.

2000 Tons Dispt. Sea Speed 24 Knots.

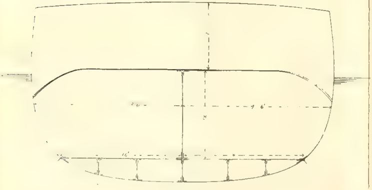
Fig 18



PLAN VIEW BELOW PROTECTIVE DECK.

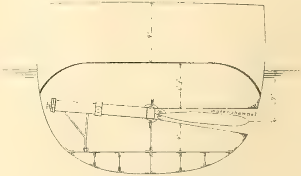
Armored Torpedo Cruiser. 2000 Tons Dispt.

Fig 17



MIDSHIP SECTION.

Fig 19



UNDER-WATER BROADSIDE DISCHARGE.

Forward. Frame 76 ft.

Fig. 20.

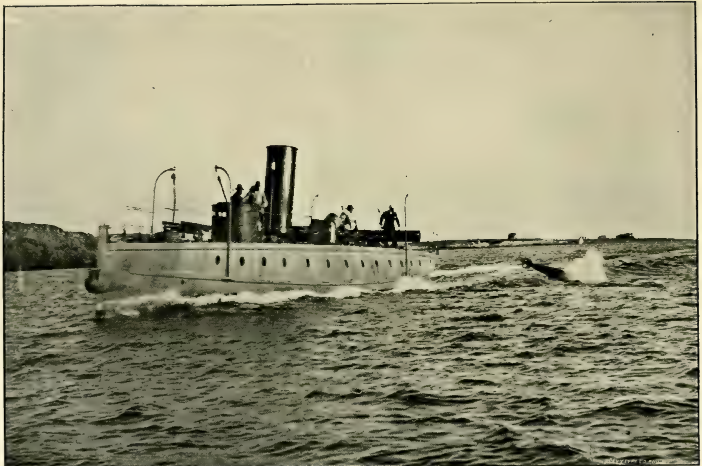


FIG. 21.

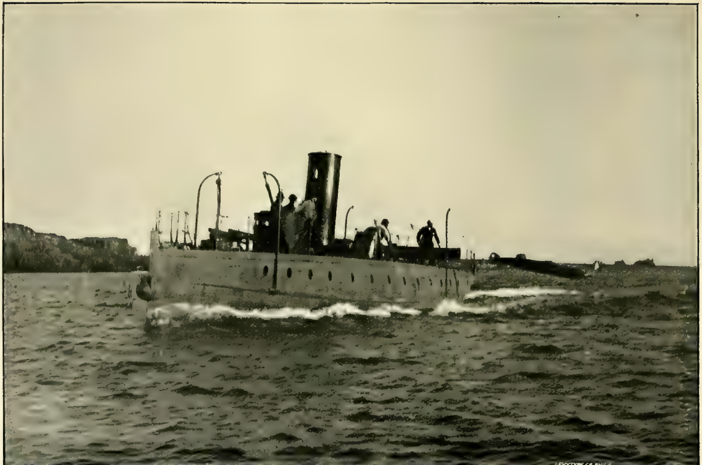


FIG. 22.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE CHEMICAL ANALYSIS OF THE THREE GUNS AT THE U. S. NAVAL ACADEMY, CAPTURED IN COREA BY REAR-ADMIRAL JOHN RODGERS, U. S. N.

By Charles R. Sanger.

This paper was intended to accompany the article by Mr. Thomas Wm. Clarke, entitled: "Notes on the Manufacture of the three Guns at the U. S. Naval Academy, captured in Corea by Rear-Admiral John Rodgers, U. S. N.," and published in these Proceedings, vol. xviii, No. 2. By an unfortunate misunderstanding the analysis was delayed until Mr. Clarke's article was in print, and the two papers could not be published together. As the analysis confirms Mr. Clarke's conclusions, I still think it well to publish it, and Mr. Clarke appends a note with comments on the results.

Mr. Clarke's exhaustive investigation can only be briefly referred to here. The guns bore inscriptions which were translated by the Chinese scholar, Wong-Chin-Foo, of New York. The dates of manufacture of two of the guns were conclusively determined to be 1680 and 1665, respectively, and these two were of a more advanced type than the third, to which Mr. Clarke assigns the date 1313, though this date is more a matter of conjecture than the others. It is very conclusively shown that these guns owed their manufacture in no way to Europeans, but were conceived and executed solely by the Chinese themselves. They point to a great advance in metallurgical skill, and it is of interest to see in what proportion the constituents of the alloy were mixed.

The method of analysis of all the guns was essentially the same, and differed very slightly from that usually employed in the analysis of bronzes. As the object of the investigation was mainly to determine the proportions of the chief constituents of the alloy, the exact determination of the accidental impurities was not carried out,

although the determination was made where it could be conveniently done in the course of analysis.

Portions of the gun were rubbed with sand-paper to remove the weathered surface, and borings were made in several places with a hard steel tool. During the boring the hardness of the alloy was found to vary as the tool advanced, but there was no regularity about this, and it could not be determined that any one of the guns had been exposed to a more scientific process of cooling than the others.

The borings were mixed, washed with ether, dried quickly at a gentle heat, and bottled while still warm. For analysis, they were dissolved in nitric acid, digested at a gentle heat for some time, and evaporated to dryness on the water-bath. The residue was then digested with more nitric acid, evaporated nearly to dryness, and taken up with hot dilute nitric acid. After standing over night, the stannic hydroxide was filtered, washed with dilute nitric acid, and finally with hot water. In some cases the filtration was effected by means of the Gooch crucible ; in others, the stannic hydroxide, after incineration of the filter-paper, was moistened with nitric acid, and, after expulsion of the excess of acid, ignited to a constant weight. The stannic oxide thus obtained was free from copper, but no attempt was made to determine any traces of silica.

The filtrate and washings, after separation of the tin, were evaporated with a slight excess of sulphuric acid to dryness, and re-evaporated until the nitric acid was completely expelled. A small amount of water, with a few drops of sulphuric acid, was then added, and, after cooling, an equal bulk of alcohol. After standing over night the precipitated plumbic sulphate was filtered by means of the Gooch crucible, washed with dilute alcohol, and ignited at a low heat. A qualitative test showed the precipitate to be plumbic sulphate.

The filtrate and washings from the plumbic sulphate were evaporated to a bulk of about 50 cc., transferred to a weighed platinum dish, and electrolyzed by a weak current, twelve hours being taken for the precipitation. After decanting the supernatant liquid, the copper film was washed with water, then with strong alcohol, and quickly dried in an air-bath at a low heat.

The liquid from the electrolysis was evaporated to a small bulk with addition of a few drops of nitric acid, and ammonia was added in very slight excess. The precipitated ferric hydroxide (+ aluminic hydroxide, etc., if present) was filtered, washed with hot water, and ignited. The presence of alumina or other oxides in the ferric oxide was not sought for.

To determine the zinc, the filtrate from the iron was evaporated, and boiled with an excess of sodic carbonate until no further evolution of ammonia was perceptible. The precipitated zincic carbonate and silica,* after washing, were ignited and weighed. The residue was digested for some time with moderately strong hydrochloric acid, and the silica remaining was ignited and weighed. From the loss in weight was calculated the amount of zincic oxide present. The filtrate from the digestion with hydrochloric acid showed the presence of zinc by qualitative tests.

The amount of sulphur was determined as follows: After solution of the alloy in nitric acid and separation of the stannic hydroxide, the solution was precipitated with baric chloride, and the precipitated baric sulphate washed and ignited.

Though a complete analysis from one weighed portion was carried out in some cases, yet a separate determination was often made under the same method of separation.

Ordinary qualitative methods failed to show the presence of arsenic and antimony in the guns. These were, however, tested for, both in the stannic oxide and in the first filtrate, by the Berzelius-Marsh method, and, in one case, the presence of antimony was determined in the mirror.

The analytical data are as follows:

Gun of 1680.

I.	1.3302	gramme	gave	0.1885	gramme	SnO_2, = 11.11	per	cent.	of Sn.
II.	1.7996	"	"	0.2574	"	SnO_2, = 11.20	"	"	of Sn.
III.	0.4586	"	"	0.4043	"	Cu, = 88.14	"	"	of Cu.
IV.	0.4738	"	"	0.4180	"	Cu, = 88.22	"	"	of Cu.
III.	0.4586	"	"	0.0038	"	ZnO, = 0.66	"	"	of Zn.
IV.	0.4738	"	"	0.0036	"	ZnO, = 0.61	"	"	of Zn.

Taking the mean of these analyses, we have as the composition of the gun:

Copper	88.18 per cent.
Tin	11.16 " "
Zinc	0.64 " "
	99.98

Traces of lead, arsenic, and iron were found.

* Partly from the sodic carbonate itself, partly from the action of the sodic carbonate on the glass.

Gun of 1665.

I.	0.3044	gramme	gave	0.0338	gramme	SnO_2,= 8.70	per	cent.	of Sn.
II.	0.4876	"	"	0.0539	"	SnO_2,= 8.67	"	"	of Sn.
III.	0.4486	"	"	0.0491	"	SnO_2,= 8.58	"	"	of Sn.
IV.	0.8895	"	"	0.0656	"	$PbSO_4$,= 5.04	"	"	of Pb.
II.	0.4876	"	"	0.0365	"	$PbSO_4$,= 5.11	"	"	of Pb.
V.	0.4097	"	"	0.3498	"	Cu,=85.37	"	"	of Cu.
II.	0.4876	"	"	0.4157	"	Cu,=85.25	"	"	of Cu.
III.	0.4486	"	"	0.3835	"	Cu,=85.49	"	"	of Cu.
II.	0.4876	"	"	0.0021	"	Fe_2O_3,= 0.30	"	"	of Fe.
III.	0.4486	"	"	0.0017	"	Fe_2O_3,= 0.27	"	"	of Fe.
II.	0.4876	"	"	0.0037	"	ZnO,= 0.61	"	"	of Zn.
III.	0.4486	"	"	0.0039	"	ZnO,= 0.70	"	"	of Zn.

The mean of these analyses gives the following composition for the gun:

Copper	85.37	per	cent.
Tin	8.65	"	"
Lead	5.08	"	"
Iron	0.29	"	"
Zinc	0.66	"	"
	100.05		

Traces of arsenic and antimony were found.

Gun of 1313.

I.	0.9206	gramme	gave	0.1208	gramme	SnO_2, = 10.28	per	cent.	of Sn.
II.	0.8577	"	"	0.1133	"	SnO_2, = 10.35	"	"	of Sn.
III.	0.6905	"	"	0.6069	"	Cu, = 87.90	"	"	of Cu.
IV.	0.4853	"	"	0.4275	"	Cu, = 87.88	"	"	of Cu.
III.	0.6905	"	"	0.0094	"	Fe_2O_3, = 0.95	"	"	of Fe.
IV.	0.4853	"	"	0.0067	"	Fe_2O_3, = 0.97	"	"	of Fe.
III.	0.6905	"	"	0.0042	"	ZnO, = 0.49	"	"	of Zn.
IV.	0.4853	"	"	0.0017	"	ZnO, = 0.28	"	"	of Zn.
III.	0.6905	"	"	0.0154	"	$BaSO_4$, = 0.31	"	"	of S.
IV.	0.4853	"	"	0.0078	"	$BaSO_4$, = 0.16	"	"	of S.

The mean of these analyses gives the composition of the gun as:

Copper	87.89	per cent.
Tin	10.32	"
Iron	0.96	"
Zinc	0.39	"
Sulphur	0.24	"
	99.80	

No arsenic nor antimony was found.

The following table gives a comparison of the composition of the three guns:

	Copper.	Tin.	Lead.	Iron.	Zinc.	Sulphur.	Arsenic.	Antimony.	Total.
Gun of 1680,	88.18	11.16	Trace.	Trace.	0.64	Trace.	Trace.	..	99.98
Gun of 1665,	85.37	8.65	5.08	0.29	0.66	Trace.	Trace.	Trace.	100.05
Gun of 1313,	87.89	10.32	..	0.96	0.39	0.24	..	..	99.80

The presence of lead in the gun of 1665 is certainly not accidental.

The greater amount of iron and sulphur in the gun of 1313 would seem to show that the metallurgical processes at that date were not so complete as at the later dates.

The metals used in the guns of 1313 and 1680 probably did not have their source in the same ores.

The guns of 1665 and 1680 were probably cast from metals mined about the same time and smelted in about the same way.

The above work was done at the U. S. Naval Academy, and I have to thank my assistant, Mr. Charles T. Whittier, for most of the determinations.

WASHINGTON UNIVERSITY, ST. LOUIS, *October* 28, 1892.

NOTE BY THOMAS WM. CLARKE.

Ure's dictionary, Hunt's edition of 1867, is a convenient authority upon bronzes. Of course it does not treat of the various peculiar bronzes of late years, such as the Amsterdam ferro-bronze, or the Ajax metal, or the Uchatius metal, aluminium bronzes, or phosphor-bronzes of our present advanced metallurgy. But so far as the old alloys of copper with zinc, tin, and lead are concerned, it is probably as nearly complete as any single work.

From this it appears that actual cannon of the last part of the last century analyzed: Copper, 89.360; tin, 10.040; lead, 0.102; silver, zinc, iron and copper, 0.498 (vol. i, p. 492). In other words, the formula was in substance 9 of copper to 1 of tin, with a little lead for fluidity. A Roman sword analyzed: 85.70 of copper and 10.02 of tin, with a probable formula of 8 to 1. The curious metallurgy of the Assyrian bronze shell which Layard found in the palace of Sennacherib, and which has since been called the leg of the throne of Sennacherib, analyzed: copper, 88.37; tin, 11.33, with a probable formula of 8 to 1, if we do not count loss by oxidation, or 7½ to 1 if we allow for that. Papacino d'Antoni, in studying the qualities

of bronze for a cannon a century ago, fixed the proportions of 100 of copper to 12 or 14 of tin, or somewhere between 7 of copper to 1 of tin and about 8 of copper to 1 of tin, while Lamartillière determined in 1787 that from 8 to 11 per cent. of tin should be employed in 100 of bronze, or, in other words, from 8 to 10 parts of copper to 1 of tin.

Analysis of ancient coins shows that the proportions of copper to tin varied from that of 5 to 1 to that of 16 to 1, with additional elements which in some instances were two or three times the amount of tin or a third the amount of copper, and in others as little as a mere trace.

The best steam metal of to-day for high-class work, I have found by examination of foremen of bronze foundries, is made of nine or ten parts of Lake copper and one part of East India tin (Banca or Straits), with occasionally, perhaps usually, one per cent. of lead or less added to lower the melting-point and save the tin from oxidation.

The bronze weapons of Troy found by Schliemann vary in composition, from the lower stratum to the upper, from the ratio of twenty of copper to one of tin to the ratio of ten of copper to one of tin.

We are then authorized to believe that from about B. C. 1000 till now, the ideal bronze for tensile strength and hardness has been about 9 copper to 1 tin.

This is the weapon-bronze of Troy, of Greece, of Rome, presumably of Assyria, and of the Chinese gun of 1313.

	Copper, Iron and Sulphur.	Tin.	Ratio.
Gun of 1313,	89.01	10.32	9 : 1

The iron and sulphur were counted above with the copper as undoubtedly derived from the copper ore. The ratio of the two metals was within the best European limits of 1770.

The gun of 1680 has the lower formula of 8 copper to 1 tin, which the European experiments of 1787 determined was the extreme allowable proportion of tin for the best gun-metal.

The composition of the gun of 1665 curiously checks the history of the times. Tin is a most sensitive index of the condition of international commerce. Saxony, Bohemia, and Spain furnish small supplies; Cornwall puts out a good deal more than half the world's supply, and the Malay peninsula and its south-trending islands

nearly all the rest. The world probably requires to-day less than fifty thousand tons a year. In 1665 it did not probably consume three thousand tons, and half of that was Cornish. The Chinese are said to have some tin-washings, and to smelt a small indigenous supply, and China must always have relied almost wholly on Straits tin brought in by sea.

When the Chengs ruled the sea from their Formosa stronghold, they pillaged the flotilla of China down to the smacks and market boats of its shore fishery, and ravaged and plundered its coasts for three marine leagues inland. Only the vassal kings of Qwang Tong and Fokien maintained occasional foreign relations by a surreptitious, almost a treasonable, tribute to the toll-taking corsairs of the Formosan prince. In this political condition a scarcity of tin must have been an early and notable result. Old metal would be sought on every hand, and adulteration practised in its largest limit.

Those familiar with the early Chinese curios brought to America will recall some carved or lacquered tea chests of a capacity of forty pounds or less, with locks and keys, each of which boxes contained an interior metallic shell not made of sheet lead and paper like the ordinary "tea-lead," but of considerable thickness, often ornamented with decorative patterns on top. These inner coffers had a central neck, a jar-cover which fitted over it, and an inside cover which fitted into it, and were said to be of block tin. They really carried a notable per cent. of lead. The use of such an old metal would account for perhaps a quarter of the lead found, but not for more. The percentage of lead in the gun of 1665 must have been caused by a positive dearth of tin and an attempt to find a substitute. This proof that foreign commerce was cut off shows a curious mechanical result from a political situation.

The form of these cannon, with their hollow cascables and their breech-block recess evidently produced by coring or by employing a three-part mold, shows high technical skill in the artizans. This is also shown by the finish of the recessed cartridge chamber in the ear of the barrel. Not very conclusive trials of hardness and examination of textures of the metal lead me to the opinion that the barrel was cored from end to end, and that the guns were cast upright, muzzle down. They seemed to be a little harder and denser at the muzzles than at the cascables, and not to vary on transverse planes.

From the fact that each gun is of special design, and differs from the other in ornamental detail and in the emplacement of the trunnions

with regard to the bands, one is warranted in saying that these guns were severally modeled in loam by the modeler, as bells and hollow-ware are molded, and, from the fact that Chinese art furnishes so few replicas, one is perhaps justified in saying that the use of patterns was unknown to it until Father Verbeist introduced them about 1678. His guns were certainly cast from patterns, and perhaps it was this art that he taught.

U. S. NAVAL INSTITUTE, NEWPORT BRANCH.

OCTOBER, 1892.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XXIV.

On account of its value, we reproduce at length, from the J. Soc. Chem. Ind. **11,** *203–212*, 1892, Oscar Guttmann's paper on "The Dangers in the Manufacture of Explosives." With a few exceptions, the dangers in connection with explosives may be summed up in the terrible word "explosion." Those who have witnessed one are never likely to forget the impression. A sharp report, huge red flames shooting towards the sky, followed by indistinguishable dark masses, then a dull shower of falling pieces, followed by a dead silence. Where a second ago a neat-looking building stood, and busy hands were working, there is now a deep hole in the ground, and all around at great distances lie scattered the fragments of house, machinery, and workers. It is difficult even to identify these last. Their clothes, if not of wool, are burnt away, their features are no longer recognizable, and sometimes a boot, or a limb, or a mark on the body is the only clue. The cause of the explosion can rarely be traced with certainty. Whoever has read the reports of Her Majesty's Inspectors of Explosives will have nearly invariably found more than one possible cause given, but they will at the same time have been astonished to find a power of generalization displayed which has never yet failed to teach some sound moral for the benefit

* As it is proposed to continue these Notes from time to time, authors, publishers and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address, Columbian University, Washington, D. C.*

of those concerned. Unfortunately such reports are published only in Great Britain, and the few short notices which reach other countries are quite insufficient to give manufacturers adequate information to enable them to provide effectively for the protection of their work-people and their property. A feeling that it is the duty of each one to relate his experiences has led the author to give an outline of the sources of danger involved in the manufacture and use of explosives.

It is generally agreed that an explosion must first be defined as the sudden decomposition of a mechanical or chemical mixture into its components, whereby in a short space of time a great pressure is developed. Such an explosion may be started by different means, and they are by no means the same in each case. Sometimes ignition will start the decomposition, sometimes a shock, friction, an electric spark, vibration, sudden heating, etc.; but as a rule it is necessary, as Sir Frederick Abel pointed out first, that a certain amount of vibration, and vibration of a distinct nature, be generated as a result of either of the above causes, in order to produce explosion.

The explosion is quicker, the larger the number of vibrations in unit time. The stronger the effect, the higher the heat produced and the larger the quantity of gases developed, as their expansion increases in proportion to their temperature. An explosion has the maximum effect when the vibrations, the heat, and the quantity of gas reach their maximum at the same time.

Here may be mentioned some of the more conspicuous examples of explosions. Chloride of nitrogen explodes when thrown into boiling water. If a minute piece of paper, smeared with iodide of nitrogen, the temperature of explosion of which is 212° F., be allowed to fall from a height of about 3 feet, it will explode on touching the ground. If such a piece of paper is put on a base-viol and the E chord is struck, it is not influenced, but if the G chord be struck, which gives more than 60 vibrations in the second, it explodes. If a gunpowder mixture be ignited in a tamped bore-hole it burns away by layers until the pressure of gas and heat cause explosion. If dynamite be ignited in this way it will simply burn without detonation. If laid on an anvil and struck sharply at an angle ("glancing blow"), all explosives in practical use will detonate. Dynamite explodes between steel and steel when 5.63 foot-pounds of work are done upon it (0.78 kilogramme-metres), gunpowder at 56 foot-pounds (7.57 kilogramme-metres); but whereas the explosion travels through the

whole of the gunpowder, dynamite, as a rule, only detonates in the part struck by the blow If a dynamite cartridge be exploded on the top of a gun-cotton charge the latter will only burn away, but if the places are reversed the gun-cotton is sure to detonate the dynamite. Each explosive has a certain temperature beyond which it cannot be heated suddenly without detonation. This temperature is, for example, 212° F. for iodide of nitrogen, from 356° to 363° for nitro-compounds, and 518° to 608° for gunpowder.

It is therefore obvious that an explosion is not solely due to the explosive being heated to a certain temperature. In fact, the shock or friction may be quite insufficient to raise the temperature to any appreciable extent, even if the shock be concentrated on a single point, as in the case of a "glancing blow."

On the other hand, anything which is likely to produce vibrations of a sufficient amplitude and frequency in the explosive should be carefully guarded against. Thus, for instance, it is well known that a tuning-fork will give a greater number of vibrations if struck against an object of steel than against brass, stone or wood; and the same applies to any shock against an explosive lying between different bodies. Steel against steel is the most dangerous, wood against wood the most harmless. Yet it has been proved by Dr. Dupré that a glancing blow with a broomstick against a wooden floor will cause the explosion of most explosives. Of course it depends greatly in what condition the explosive itself is. A blow given to a full cartridge of blasting gelatin may be quite harmless; but if sufficient force be used to flatten the cartridge and expose the last thin layer to a sufficient amount of shock, then an explosion of the whole cartridge may follow. There is also a great difference between the explosive being warm or cold. When warm, explosives are as a rule more sensitive, both to decomposition and to shock or friction.

The causes of explosions may be placed under two headings, mechanical and chemical. The mechanical causes are mainly due to shock, friction, or ignition of some sort. The chemical causes vary with the nature of the explosive. Mechanical mixtures, such as gunpowder, roburite, etc., are, under ordinary circumstances, exempt from dangerous chemical changes; but chemical compounds have always a certain amount of instability, which can only be avoided by careful manufacture. Of course there are also mechanical mixtures which are liable to decomposition, and I need only mention the chlorate mixtures, which, especially in the case of fireworks, have led to many accidents.

In the following account each explosive will be dealt with separately, and the dangers attached to it at each stage of its manufacture pointed out. Of course only those explosives which are actually manufactured and in use will be spoken of, it being left to you to draw your own conclusions, by the similarity of cases, when other explosives come under your notice.

Gunpowder.—First by seniority and by the number of factories making it come gunpowder and its imitations. In this case, as in that of every other explosive, a very important condition is that the materials employed should be of the greatest possible purity, both chemically and mechanically.

In the nitrate (saltpetre, sodium nitrate, etc.), chlorine is the principal impurity. Although in the case of true gunpowder no saltpetre is now used which contains more than one ten-thousandth part of chlorine, yet with gunpowder imitations, especially where sodium nitrate is used, this is not always the case. An assistant of mine once made some powder mixture, extracted the nitrate, which contained a large amount of chlorine, from it, evaporated the solution in a porcelain dish to dryness and complete fusion. He then allowed it to cool, and after some time began to move the cake with a glass rod, when suddenly the whole flashed up. In this case it is evident that some nitrogen chloride had been formed, the liability of which to explosion by the slightest vibration is so well known.

Care has also to be taken that no saltpetre or powder comes in contact with a soldered joint. Weber found in a particular case that nitrate of tin was formed, of which there is an explosive variety; this has caused frequent accidents.

The charcoal presents no other danger than that of spontaneous combustion. It is a good practice to have the charcoal first ground in separate machines. Spontaneous combustion is due to the capacity charcoal has of absorbing and condensing the air, producing thereby heat. This may sometimes take place suddenly, as, for instance, when a piece of charcoal is broken, and the interior, which has preserved its absorbing power, is brought into contact with moist air.

The sulphur is now generally ground before mixing it with the other ingredients. Although by quick grinding a large amount of heat may be produced, this is scarcely ever sufficient to fire the sulphur. But sulphur mills very often take fire, and this is chiefly due to the well known electrical qualities of sulphur, which are made evident by the friction and heat in grinding. A friend of the author

connected his sulphur mills with the earth by means of copper wires so as to carry away the electric charge as it was produced; since this time he has never had a sulphur mill fire.

If a ventilator is used to carry away the sulphur dust, its exhaust-pipe should go into a collecting chamber, as sulphur dust is dangerous.

In this country stamp mills are no longer used for the incorporation of gunpowder, but elsewhere they still exist. They have generally wooden beds and brass stamps, and but for the presence of grit, or some broken metal parts, they are safe enough, provided the powder is frequently "liquored." Still, most of the accidents occur with them, as these two conditions of safety are often accidentally absent, and the great amount of dust, thrown in the air by the violent blows of the stamps, takes fire easily by a spark, or by the friction of a stamp-pole.

Mixing drums were formerly largely used, and seem to be coming into use again in this country, for certain kinds of powders. As they are made of "sole" leather or wood with brass or wood balls revolving in them, there should be no other danger in them than comes from overheating due to the quick movement. There is still another source of danger which will be dealt with presently.

The machines chiefly used for the intimate mixture of the gunpowder ingredients are the "incorporating mills," having generally pans and runners of cast-iron. Sometimes the beds are made of wooden blocks on edge. Incorporating mills are known to explode from time to time, and formerly the well-worn excuse of a match or a nail having got into the mill used to be a readily accepted explanation of the accident. Such an occurrence of course is possible, but must be very rare indeed. The chief cause is faulty construction of the mills. The runners weigh from four to five tons, and if the cake in the course of milling becomes dry and hard, the runner may lift in passing over a thicker piece and then fall down on to a thin one. Good incorporating mills are now made in such a way that the runners always remain one-sixteenth inch off the bed, so that the iron can never come in contact with iron. Another cause, which applies to mixing drums and nearly all other powder machinery, is electricity accumulated by the friction against the sulphur. Some years ago the author devised the "earthing" of incorporating mills, and he believes that the number of accidents has considerably diminished where his suggestion has been adopted. It is known that many of

the explosions in incorporating mills happen where they are suddenly stopped or started after a stoppage, whereby a great amount of vibration is of necessity set up in a single moment. Many accidents happen also in removing the cake from the bed, or when repairs are being made. It is essential and rightfully enforced by Her Majesty's Inspectors that the cake should only be taken away when damp, and that no repair should be done without having previously thoroughly washed and cleaned the whole building. The use of brass tools in such a case is only a diminution of the risk, and is not by any means a safeguard against accident, and even wooden implements should only be used after the charge is well moistened. To prevent communication between one mill and another, which very often are driven in pairs from one water-wheel or line of shafting, the drenching apparatus has proved to be very effective. Briefly, this is a water-tank placed on the top of a mill, and held in equilibrium by a "shutter," a flat lever board, which, when raised in the least degree, upsets the tank. All the shutters are connected by a shaft, so that when an explosion in one mill takes place, all the other charges are immediately drowned.

When an incorporating mill explodes, the building only is, as a rule, damaged, and that not always much. A friend of the author's has adopted the excellent system of constructing the roof of the building with a very light framing, and securing the whole roof by two loose wooden pins only. If an explosion occurs the roof is simply lifted, giving enough opening to the gases to escape before sufficient pressure to materially damage the building can be set up.

The mill cake is next powdered in a "breaking-down machine," which is essentially a roller mill with one pair of grooved and one pair of plain rollers. This machine requires no more attention than any other powder machinery, except that it should be so made that the pressures on the rollers cannot exceed a certain limit. This is generally done.

Next comes the pressing, which is now generally done by hydraulic machines, roller presses being very rarely used. Formerly this pressing was done by placing in a square wooden box with hinged sides a layer of powder meal and a brass plate alternately, and then pressing a block of hard wood into the box. This caused the powder to adhere so strongly to the sides of the box that it required a good deal of force to open it, and sometimes occasioned accidents. Nowadays the damp powder meal is, as a rule, laid on an ebonite

plate, another placed on the top of it, and so on, layers of powder and ebonite occurring alternately until the required height is reached. This way of pressing is comparatively safe, provided great care is taken to keep the presses clean, and the hydraulic ram is not allowed to fall down too quickly. But there is again the danger of electricity, which in this case especially must not be underrated. The charge of a cake press with ebonite plates can practically be considered as an electric pile, and a large amount of friction or electric influence from outside may cause a sufficient electric charge to give off sparks. Several cases have been known, and the following instance occurred at a large Continental factory. The workman, having just finished charging, opened the valve for the hydraulic pressure, when he became aware of an approaching thunderstorm. According to his instructions he left the building and returned after the thunderstorm had passed away, but when he began to discharge the press it exploded. The man died, but stated before his death that in undoing the cakes a spark four inches in length came on his finger.

It is therefore advisable to take great precautions in using ebonite. It is a very convenient material, being very tough, of smooth surface, hard and not subject to much wear and yet sufficiently elastic; it is, therefore, largely used for plates in cake presses, for the lining of hoppers in granulating and sifting machines, etc., but care must be taken that no electricity can accumulate even under unfavorable circumstances.

The reduction of the powder cake into grains is done by a machine similar to that used for breaking down the mill cake; the grains formed are continuously classified as they fall from the rollers by sieves placed underneath. There is a large amount of dust produced in this operation, and the author has not yet seen a single graining machine where the escape of dust into the room has been perfectly avoided, but he has seen many houses where the air looked worse than a London fog, and where with open doors you could see the cloud of powder dust coming out for more than three yards. As a matter of course, there is shafting in the house, the graining machines themselves contain a number of cog-wheels, bearings, etc., and sometimes the shafting itself is driven by a cog-wheel from another line of shafting. These cause a good deal of noise, which, together with the darkness in the room, produces a very uncomfortable feeling.

In many factories the graining is still done by the Lefebvre system, which consists of one or more sieves oscillating either longitudinally or in a circle, in which a weighted boxwood disk, hewn like a millstone, is moved to and fro, thereby breaking the cake. This way of graining produces, of course, still more dust.

In some places a ventilator may be found which draws out the powder dust though an opening in the building, and deposits it on sheets of cloth, but it is never efficient enough to clear the atmosphere of the room. It is the author's belief that a suitable casing round the graining machine, and a hood on the top in connection with a good exhaust, leading in a depositing chamber, would answer the purpose much better. No cog-wheels should be allowed on the shafting inside the building. They do not always gear perfectly, and wear out in time, which causes dangerous knocks, and it would perhaps be advisable to put the shafting altogether outside the house, unless it runs at a low speed. The bearings of the graining machine should be provided with constant lubricators, such as Stauffer's solid grease cups, which prevent the inconvenience of the oil dripping about, and keep the bearings constantly greased.

During the glazing, rounding, and sieving, the powder is subjected to a constant friction of its particles against each other; and during the glazing especially, where there is still a large amount of moisture, a good deal of heat is developed. The plugs in the glazing barrels must be opened at regular intervals to allow the escape of steam formed, and care should be taken with all these revolving machines to carry away any electric charge that has accumulated, which is easily done.

The drying of the powder is no longer done in the open air, however convenient this may have been. There was always the risk of grit flying into the powder, and of concentration of the sun's rays, if exposed to it. Artificial heat is now generally resorted to, and in very few cases only are the fumes of a stove carried in pipes to the drying house. Steam, hot or warm water, are nearly always adopted now. The introduction of steam or hot water pipes into the building itself is objectionable, as a certain amount of dust, which is always produced in charging and emptying the trays, accumulates on the hot pipes. Warm water pipes increase the time of drying a little, but are not open to this objection. The best way is certainly to have a steam or hot water stove outside the building, and to drive, by means of a fan, a current of air over the stove into the drying cham-

ber. This allows an even temperature to be kept, and removes all danger, provided that the air inlet be so arranged that the current of hot air cannot pass directly over a layer of powder.

Sometimes the press cake is cut in large cubes for the so-called pebble or cube powder. No special allusion may be made to these machines, whatever may be their construction, as the exclusion of hard blows, the attention to knives, bearings, etc., is the same as with all other powder machinery.

The process which requires the most attention, and which is not always in expert hands, is that of compressing the powder into prisms, cylinders, pellets, etc. There are two classes of presses in use, lever and hydraulic presses. With a lever press generally the powder is charged into a mold, closed at the bottom by a piston, and another piston is brought down on the top by a lever actuated by an eccentric. Of course there is a great variety of such presses. Some have a "block" with many holes, into the bottom of which comes a disk, then the powder charge, then a piston, and the whole goes under a press. In some presses the mold revolves on a table, and its holes are alternately opposite a plain part and a perforated part of the table, and, at the same time, subject to a piston compressing the charge, and, on another part, to a longer piston forcing the compressed cartridge through the hole in the table, whence it falls out in a receptacle. Sometimes a hopper slides over the mold, fills it, glides away, and the charge is forced out. Sometimes the mold is fixed, sometimes it is balanced during the compression, whilst a piston enters the mold from the top and from the bottom.

These latter presses are, perhaps, the best in the way of lever presses, provided the mold be guided vertically, and one of the two pistons has a safety arrangement, to prevent excess of pressure. Lever presses, where more than one cartridge is pressed at a time, are objectionable, as they seldom have a safety arrangement, and to make such a one effective would cost as much as a suitable hydraulic press.

It is well known to everybody who has had to do with the compression of pulverulent substances, that it is most difficult to have a number of molds filled with exactly the same quantity in each. Even little hoppers, which open at a certain weight, will fail to give more than a rough equality. Also the state of the atmosphere and the shape and diameter of the mold make a difference, as does also the size of the grains in the case of gunpowder.

Although gunpowder can bear a great pressure without injury, yet it is not advisable to do much in this direction, as it is very easy to get local overheating by the presence of a foreign particle or a hard grain. Also the more powder is compressed, the more it will adhere to the mold, and in pushing out the cartridge a greater pressure will be required. It is the friction thus caused which produces the greatest heat, and where the most danger exists. When, therefore, a number of molds are not equally charged, and they are all compressed by pistons fixed on a common head, the cartridge which contains most of the powder may, at a certain stage, receive all the pressure intended for the lot, and will, in any case, get more than its share. Hence the necessity of an arrangement to prevent an excess of pressure. This can be done by weighted levers on the bottom pistons, or, much better and simpler still, by keeping each mold independent and movable.

The same applies to hydraulic presses. Most of them have one ram only, so that the cartridge, which may vary from 1½ to 3 inches in height, is far more compressed on the bottom than on the top. Those with one ram on top and bottom make a better compression, and want less pressure on either side, but they are costly and cumbersome. In neither of them, as a rule, is any arrangement to prevent an excess of pressure provided, and the best means of doing this is the movable mold.

Presses for prismatic powder, where needles of phosphor-bronze enter the molds, require careful inspection, as the slightest bend of a needle can cause breakage.

Another method of powder manufacture may be briefly mentioned, which was long ago known to the Tartars, and some nine years ago practised in this country. This method is to dissolve the saltpetre in hot water, add the other ingredients, and boil down the whole with constant stirring during the evaporation. The English system of inspection would have soon put a stop to the way in which this was done for some time on the Continent, where this process was carried out in a kind of washing copper with a coal fire underneath, and where the contents of the copper sometimes went off through part of the powder being caked at the bottom and excessively heated.

The manufacture of cocoa-powder does not differ from that of ordinary gunpowder except in the preparation of the charcoal, which is no more dangerous than the work of a rag-boiler.

In connection with gunpowder may be mentioned also the manu-

facture of safety fuses. This presents no particular danger, except that in spinning the first layers of the fuse, where a fine stream of powder falls in as the fuse is formed, the excess of powder falls on the floor, covering a large area, requiring precautions to be taken against friction or the fall of the weight which keeps the fuse stretched.

Nitro-compounds.—The next group to be dealt with are the so-called nitro-compound or chemical explosives. These are produced on a very large scale, and gain daily in importance; but their manufacture involves generally a great amount of machinery and apparatus, and the knowledge of all the accompanying circumstances is still far from being perfect, besides being sometimes of a very complicated chemical character.

Nitro-compounds are liable to explode at a lower temperature, are more sensitive to concussion and friction than gunpowder, and in addition, as products of chemical action, are liable, under unfavorable circumstances, to undergo chemical changes which may render them unstable.

A nitro-compound is generally formed by the action of nitric acid on a hydrocarbon, sulphuric acid being added in order to take up the water formed during the process and to keep the nitric acid as far as possible at its original strength, so as to avoid the formation of lower nitro-compounds, which would either reduce the force of the explosive, or even render it unstable.

Comparatively the least dangerous to manufacture are gun-cotton and collodion cotton. With the exception of the nitration and the compression into cartridges, the whole process is worked with a large excess of water, and although it is quite conceivable that a particle of gun-cotton surrounded by water may explode when struck by a heavy weight, yet such a case is hardly likely ever to occur.

The cotton has to be very carefully purified from resinous matter and soluble substances, as they would form unstable by-products if allowed to remain. This is usually effected by boiling the cotton in a solution of soda. The nitration is done in England by dipping the cotton into the mixture of nitric and sulphuric acids, which are contained in a cast-iron vessel, squeezing it roughly out on a grid, and then letting the nitration complete in earthenware pots, which stand in running water. On the Continent they employ nitrating machines, consisting of a cast-iron vessel with a lid screwed on, having a false bottom which can be moved by means of a screw passing through

the lid. The cotton remains in the machine during two hours, and then the false bottom is lifted towards the lid, thus squeezing the cotton out. In another factory suction is applied underneath the false bottom to drain the cotton.

The nitrated cotton is further deprived of the bulk of its acid by treatment in a centrifugal machine, whence it is passed as quickly as possible into a washing machine.

Care has to be taken that the acid cotton remains constantly under the acid or the water, or at least well covered, else, as it absorbs moisture rapidly, it decomposes, and once a decomposition is started it is almost impossible to stop it. This decomposition is attended by large volumes of red fumes, and sufficient means of ventilation and escape for such have to be provided from the outset in case they are formed. The warmer the mixture, and the less liquid acid it contains, of course the more liable it is to decomposition, hence it is on warm and moist days centrifugal machines are most liable to fire; this seldom happens in the winter, unless some water, oil, or other foreign material falls into it.

Once it is immersed in the washing machine, whose water has to be constantly changed, the gun-cotton is no longer subject to sudden decompositions during the subsequent processes of manufacture, but the acid still remaining in it has to be eliminated with the greatest care, or else a gradual decomposition will take place. I will not detail this manufacture, as it is well known; suffice it to say that gun-cotton which stands the English Government's heat tests is quite safe under all ordinary circumstances.

The compression of gun-cotton into cartridges requires far more care than that of gunpowder, as this is done in a warm state, and gun-cotton, even when cold, is more sensitive than gunpowder. When coming out of the centrifugal machines the gun-cotton should always pass through a sieve, in order to detect nails or matches which may by chance have got into it. What has been said as to gunpowder presses applies still more to those for gun-cotton, although the latter are always hydraulic presses. Generally the pistons fit the mold perfectly, that is to say, they make aspiration like the piston of a pump. But there is no metal as yet known which for any length of time will stand the constant friction of compression, and after some time the mold will be wider in that part where the greatest compression takes place. The best metal for this purpose has proved to be a special steel made by Krupp, but this also is only

relatively better; for pistons I prefer hard cast-iron. If the position of the molds and the pistons is not exactly the same in all cases, what the Germans call "Ecken" (English, "binding") will take place, viz., the mold will stand obliquely to the piston, and a dangerous friction will result.

For certain purposes, such as torpedoes, engineers' cartridges, etc., the gun-cotton has to be turned in a lathe, or drilled or planed. This should always be done under a constant stream of water, to keep the tool cool, as well as the gun-cotton in contact with it.

Of course, it is necessary to protect the man working the hydraulic valves during compression. At Waltham Abbey they have a curtain made of ships' hawsers which is at the same time elastic and resistant. The author has found from experience that a partition wall 12 inches thick, made of 2-inch planks, and filled with ground cinders, gives very effective protection. There are scarcely ever more than 5 lb. of gun-cotton under pressure at the same time, and in the case of an explosion the parts projected embed themselves in the timbers. The roof or one side of the building should be made of glass, so as to give the explosion a direction, and as a matter of fact it will not injure the walls of the building, even if they are only one brick thick.

The drying of gun-cotton is no less attended with risks, if it is done by improperly constructed arrangements. It is generally accepted that the drying should not take place at a higher temperature than 104° F. To secure this an electric alarm thermometer should be provided. If a current of hot air passes over a layer of gun-cotton, the cotton becomes electrified, and most, if not all, the fires in gun-cotton drying houses are due, in the author's opinion, to a neglect to carry away this electricity.

I am indebted to Mr. Walter F. Reid, F. C. S., for much information in this respect. He was the first, so far as the author knows, to make metal frames, carriers, and sieves, upon which is secured the cloth holding the gun-cotton, and to earth them.

In drying-houses there is a large amount of gun-cotton dust produced, which deposits on walls, floors—in fact everywhere. This dust, being warm, is very sensitive to friction; in fact, Colonel Cundill once told me that even the hard friction with a felt shoe had been known to fire it. The workers in these rooms should therefore always wear felt shoes or go barefooted, avoid all unnecessary friction, and frequently wash the floors and walls. The floor should be covered either with india-rubber or linoleum.

On no account should an exposed metal pipe for the conveyance of heat be allowed in the drying room. Although the heat may not exceed 104°, and the radiation of the pipe may be sufficient, yet there might be a more sheltered place, such as a bend, a corner near a wall, etc., where the quantity of heat is accumulated, and a far higher temperature reached than that of the air entering, and it is just such places that will be filled with cotton dust, which itself will serve as an accumulator of heat. An accidental blow on the metal pipe may also happen, so that it is best to exclude them altogether from the room.

The above remarks about gun-cotton apply to mixtures of nitrate and gun-cotton, such as tonite, potenite, etc.

The manufacture of nitroglycerin and dynamite is by outsiders generally considered as an extremely dangerous one, and it certainly is in the hands of untrained and inexperienced people; but if conducted by experts it is far less risky than the manufacture of gunpowder. Still, as it is essentially a chemical operation, its safety will always depend upon the amount of care bestowed on it by the work-people; it requires a great deal of supervision to be always on the watch for neglect of duty.

The sources of danger rising from the raw materials will first be considered. The nitric acid used should be reasonably free from peroxide. Opinions differ as to what is a reasonable amount, and no doubt the heat developed during the process of nitration is increased by the presence of this, a large amount of hyponitric acid; and, if sufficient care be not taken, may cause decomposition and explosion. Some say it should not contain more than 1 per cent.; but some of the most perfectly conducted factories use it with even more than 4 per cent. The author's experience has been that nitric peroxide undoubtedly produces more heat by its great oxidizing power, but as the temperature of the mixture is always kept under about 77° F., it means that the nitration will last longer, because the workman must allow less glycerin to run in, and consequently he is expected to be still more attentive. Hyponitric acid also reduces the yield of nitroglycerin considerably. As a rule, those factories which buy their nitric acid insist upon having as little hyponitric acid as possible, sometimes below half a per cent., and those which make their own acid are not particular about 1 per cent. more or less. If the process of nitric acid making is conducted in such a way that a minimum of hyponitric acid be present, it will be difficult to have more than 93 per cent. pure monohydrate, and a large quantity of weak acid will

result. If highly concentrated acid only is made, containing 95 to 96 per cent. pure monohydrate, then more heat has to be applied, which will always decompose some nitric acid into hyponitric acid. Of course, a high percentage of monohydrate and no weak acid are most to be desired, because the first gives infinitely better results, whilst the latter is of little value, and if, therefore, the hyponitric acid should be eliminated, then a costly and tedious process of bleaching is necessary. This is the reason why a dynamite factory which makes its own nitric acid has never been known to have less than 2 per cent. of hyponitric acid as an average, but some even as much as 7 per cent. A new process which the author has recently invented gives invariably less than 1 per cent. of hyponitric acid with from 95 to 96 per cent. pure monohydrate, and this is now being rapidly introduced into many factories. This process can even be worked in such a way that the acid will not contain more than one-tenth of a per cent. of hyponitric acid, and acid with even as much as 99.40 per cent. pure monohydrate has been made by this process. This is the strongest acid ever manufactured on a large scale, but there is a great amount of the possible yield lost. It may therefore be said that unless the nitric acid is after its manufacture submitted to a long and expensive bleaching, the best which can be made on a commercial scale will always contain about 1 per cent. of hyponitric acid. As it is scarcely to be expected that everybody can have the very best acid, the limit of hyponitric acid may be set at 2 per cent., which does not increase materially the danger of too much heat being developed. Beyond this limit the heat of the mixture may rapidly increase, and the workman has to be constantly on the alert to shut off the inflow of glycerin, or to apply more vigorous cooling and stirring. As it is desirable that every process should depend as little as possible on the attention of the workman for avoiding accidents, an excess of hyponitric acid should not be allowed.

Sulphuric acid and glycerin are nowadays made very pure. Arsenic may be in both, especially in the sulphuric acid, but it should never be allowed to exceed one-tenth per cent. on account of the well-known strong oxidizing action of arsenious acid.

Glycerin is a very intricate substance, so far as its use for making nitroglycerin is concerned. Of course, a large amount of organic matter, such as cellular substances from the tissue or fatty acids, are both objectionable, as they form unstable compounds during nitration. The presence of chlorine has also to be avoided, because it will

ultimately form hyponitric acid. But even if the glycerin is nearly perfectly pure, and contains nothing whatever but about 0.15 per cent. of total residue, organic and inorganic, it will sometimes happen that the nitroglycerin made is full of a bulky, flocculent matter, which prevents its separation from the acids for a very long time. This only happens with glycerin of a special manufacture, and up to now even so high an authority as Mr. Otto Hehner has been unable to find out to what component or impurity this is due.

The operations of nitrating and separating the nitroglycerin do not require more attention than that the temperature should not even at the finish exceed 86°. I do not refer by this to the Boutmy-Faucher process, which in itself had a special source of danger, inasmuch as in it the sulphuric acid was first allowed to act upon the glycerin, which caused the organic impurities to become charred and to form minutely suspended carbon particles. This prevented the nitric acid, at its highest concentration, penetrating every particle of glycerin, and sometimes prolonged the separation for days. It will be explained later on why this must have been dangerous, or is still so, as the process is still said to be used on a small scale at the French Government factory at Vonges.

It is in the apparatus used for nitration and separation that the chief danger lies, on account of their construction. The nitrating apparatus is now generally a large lead tank, with a number of cooling worms, through which cold water runs. The tanks are closed at the top, with suitable openings for the admission of glycerin and compressed air, for the escape of the fumes, and for the constant control of the temperature, also for discharging the tank either into the separating apparatus or into a drowning tank. All these arrangements of course complicate the nitrating apparatus, and require constant attention. A detailed description of the different apparatuses in use cannot be given in this paper, as it would be sufficient for a paper by itself, but some of the chief sources of danger, however, must be pointed out. First is the lead itself usually used in the construction. The combined action of nitric, nitrous and sulphuric acid on the lead is very great; but still greater is that of the fumes, when mixed with the outside air, because diluted acid attacks metals more than strong acid. The lead should be perfectly pure; some even prefer remelted old lead, as it becomes harder by remelting. If the slightest amount of zinc is present the lead is very soon perfectly honeycombed. The fumes should be drawn off

through a pipe with a good draught in it, so that the outside air cannot enter the vessel. The compressed air used for stirring and cooling should come from a storage vessel, where it can deposit all its moisture, and the pipes leading to the apparatus should ascend as much as possible, and have a drain-tap attached. All joints should be made quite tight, and the construction of the cooling worms must be well understood, as they will expand and contract, and can easily leak. It must be understood that the slightest leak of water pipe may start a very serious decomposition, and it is therefore a good plan to test the whole apparatus every morning before starting work.

The manner of introducing the glycerin is another matter for consideration. In some apparatuses where a screw paddle assists the stirring, the glycerin runs on a disk attached to it, and is therefore scattered by centrifugal force in minute drops. Sometimes a perforated pipe supplies the glycerin, and very often an injector. Those injectors which are placed near the bottom of the vessel are soon eaten away, and sometimes cause a sudden inrush of glycerin, which is of course to be avoided. Injectors or pressure vessels which blow the glycerin through a pipe are perhaps the best.

The temperature in the apparatus must be efficiently controlled; it is not sufficient to know the temperature of one part of the vessel only, since decomposition generally starts locally and then spreads over the whole mass.

The taps for discharging to the separators and to the safety tanks want very careful fixing, and it is commonly said that it is a knowledge of itself to make all the different kinds of mastic or cements that are required in a dynamite factory. Of course the taps must not be placed so that water can get into them. At the same time much depends upon what pressure there is on the tap, and one of the objections to those huge American apparatuses is that they have a column of acid 10 or more feet high resting on the taps, and exerting about 8 lbs. pressure per square inch. It is so easy to get a tap or a plug knocked out, apart from the pressure on the tank and the enormous weight of the cooling worms.

The apparatus should of course be made so as to empty itself to the last drop, and the safety tap should be sufficiently large to empty the vessel in a few minutes. Exactly the same remarks apply to the first separators and the bottles used in the secondary separation.

It might be appropriate to mention here that a decomposition in a properly constructed apparatus is a very rare occurrence indeed,

and due only to leakage, bad glycerin, or inattention on the part of workmen. Even if a decomposition should be seen starting, there is no need to drown a charge at once, or to lose one's head and run away. A decomposition, as has been mentioned, begins at one point and spreads gradually through the whole mass. A slight decomposition will develop a huge volume of dark red fumes, and is certainly alarming to the novice, but it will take sometimes ten or more minutes before it can develop into an explosion. The author has seen decomposing charges entirely saved by the coolness of the workmen, who freely used all the available means for cooling and stirring. In one instance, the acid underneath the nitroglycerin in a separator decomposed, and the man in charge, who was a new hand, in his confusion opened the nitroglycerin tap instead of the safety tap, and although the whole of the nitroglycerin had time to run into a water tank, it was more than a quarter of an hour before one could think of entering the building to drown the decomposing acid.

In the process of separating the nitroglycerin from the acids there is the danger of a prolonged contact of the two liquids, which has been fully investigated by the Home Office in reference to the Pembrey accident. Nitroglycerin dissolves in sulphuric acid, and just at the line of contact between the two liquids many of those lower nitro-compounds collect which have been formed from the impurities in the glycerin. Others collect on the top of the nitroglycerin, where they are exposed to the action of the air. Pure nitroglycerin can remain a very long time in contact with pure nitric and sulphuric acid without alteration ; but in a process where everything is impure, the lower nitro-compounds are soluble and unstable, and therefore the separation should be finished as quickly as possible. I have referred already to the glycerin retarding the separation, but there are also mechanical impurities in the other reagents which have even worse effect. If the sulphuric acid contain much lead, if the mixed acids have been in the storage tanks too long, and some lead or iron is dissolved in them, this will be suspended in minute, but bulky, quantities in the mixture of nitroglycerin and acids which leaves the nitrating apparatus. Still more marked is this effect in the case of any carbonaceous matter introduced, such as straw from the carboys, gross organic impurities of the glycerin, etc. This is the case with the Boutmy-Faucher process, where, by dissolving the glycerin in sulphuric acid, the impurities in the former are charred and delay the separation in an extraordinary way. The

worst case known to the author was one when a second-hand air vessel was bought for the storage of sulphuric acid and a thick layer of rust prevented it being seen that the vessel had formerly been coated inside with tar. The sulphuric acid became quite black from the tar, and after two days' separation only half of the nitroglycerin could be recovered.

It must be understood that the difference of specific gravity between the nitroglycerin and the refuse acids is only 0.100, the former having a gravity of exactly 1.600 and the latter about 1.700, and although the greater fluidity of the acids facilitates to a great extent the separation, yet such bulky impurities remain for a long time suspended and form contact between the more sticky nitroglycerin and the acids, thus obstructing separation.

The secondary separator receives the spent acids, which generally contain minute globules of nitroglycerin in suspension, and it is essential that they should have time to separate. This secondary separation is the weakest spot in a dynamite factory. The fact that small quantities of highly acid nitroglycerin are floating on the top of strong acid, and, even with the best ventilating tubes, are exposed to the air, may account for some decompositions, but the author believes that a careful investigation of all the facts would nearly in every case point to another cause for an accident, that cause either a leak of a water-pipe or the intrusion of some organic matter.

Some of the experiments which the author has carried out with waste acids have shown that if large quantities of glycerin are poured into waste acid (which has nearly invariably the composition of about 10 nitric monohydrate, 70 sulphuric monohydrate, and 20 water), a turbulent decomposition takes place in a very short time. If we take the process of nitration to consist of an interchange between the NO_2 group of the nitric acid and the hydrogen molecules of the glycerin until complete exhaustion of the former, then every particle of glycerin entering in excess will not be nitrated, but dissolved in the sulphuric acid, as after the formation of the bulk of nitroglycerin the nitric acid left occupies about one-fourteenth of the whole mixture, and in spite of violent stirring it is difficult to cause the little nitric acid remaining to come in contact with the glycerin particles. Besides, this nitric acid, as it is seen from the composition of the refuse acids, is in a very diluted state, and if it could easily come in contact with the glycerin, it would only form mono- and dinitroglycerin, which are soluble. Thus it will be seen

that an excess of glycerin forms a very dangerous mixture, and on two occasions at least the cause of decompositions could be distinctly traced by the author to such an excess.

It must be pointed out that a small excess of glycerin may happen with any operation, as it is impossible to calculate exactly the quantity required, and a slight variation in the strength of the nitric acid will at once alter the quantity of glycerin which can be converted into trinitroglycerin.

There is another reason why very strong acid with a rather higher percentage of nitrous acid is preferable to the reverse, as the workman can guard against overheating, but he has no means of ascertaining the total nitrating capacity of the nitric acid. But a small excess of glycerin, although just affording the amount of danger connected with the work, is still not a distinct danger, so long as proper attention is paid. It is only a large excess which can produce a sudden decomposition, and it would be impossible to stop this. This excess of glycerin need not necessarily be the consequence of an error in weighing, it can also be brought about by using too weak nitric or sulphuric acid, or by a mistake in weighing the acids for mixing. The only remedy in this case is to watch the yield of nitroglycerin. If it falls below a certain limit, then part of the glycerin must have escaped nitration, and the only plan to adopt is to at once drown the waste acids, as containing too much glycerin. With good yields of nitroglycerin and proper attention the secondary separation never gives any trouble.

As the waste acids are in most cases treated in a denitrating apparatus to recover the two component acids separately, care must be taken that every particle of nitroglycerin is removed in the storage tanks before working them up. Small drops may come up after days, and an explosion of a denitration plant in Italy was due to neglect in this direction. The storage tanks must also be protected against the weather, and have a safety tank attached, as their contents will sometimes decompose, especially in hot climates.

In the operation of washing and filtering the nitroglycerin, warm water should be used with caution, as nitroglycerin begins to evaporate at 104°, and the inhalation of nitroglycerin vapors in large quantities is injurious.

The other operations do not require more attention than with other explosives, except the formation of cartridges by lever presses, where the material falls through a funnel into a tube, and a piston on

a lever forces the dynamite out in the form of a cylindrical mass. There are two kinds of presses, one where the parchment paper is wrapped around the tube and the whole cartridge is made in one pressing, and others where the dynamite is pressed out by consecutive strokes with the lever, so that a continuous string comes out of the tube. This is broken off when it reaches the required length, and then wrapped round with parchment paper. This kind of intermittent pressing is no doubt the best, and the single stroke presses are rightly objected to by the German industrial inspectors. It is patent that in order to press out a cylinder of soft material of about four inches in length there is perhaps twenty times more force wanted than for a piece of an inch, and any metal or grit particle, or even a hard lump of kieselguhr, may produce enough friction on the tube to cause an explosion. By far the majority of the explosions in cartridge huts happened with single stroke presses. Of course, cartridge presses must be so constructed and secured as to prevent any hard blow or friction.

The manufacture of blasting gelatin, gelatin dynamite, and gelignite calls for very few remarks. As the process is carried out with the aid of artificial heating, care must be taken to avoid excessive heating, since the collodion-cotton may begin to decompose and the nitroglycerin to evaporate. The machines for mixing, if such are used, and for making cartridges must be so constructed as to avoid undue friction, and to allow of ready inspection and cleaning.

The danger of freezing has still to be dealt with. It is well known that nitroglycerin freezes at about 46° F. Dynamite and blasting gelatin will freeze at slightly lower temperatures. Numerous experiments have shown that frozen nitroglycerin and dynamite are highly insensible against a shock, and that even a bullet fired from a military rifle at 50 paces has failed to explode it, whereas soft dynamite explodes readily at 300 and more paces. Yet somehow frozen nitroglycerin does sometimes explode. To the author's own knowledge, the removing of some frozen nitroglycerin from the ground by means of a pickaxe, the sudden turning of an earthenware tap, around whose plug some nitroglycerin froze, the cleaning of vessels containing frozen refuse, and even the forcible breaking of a frozen dynamite cartridge, have resulted in explosions, and it is probable that similar instances are known to others. The author believes that the explosion of frozen nitroglycerin is due to a sudden alteration in the molecular arrangement of the frozen nitroglycerin—such as Professor

Tyndall stated in the case of ice—and the consequent production of vibrations sufficiently high to cause a detonation. This is certainly a striking illustration of the fact that explosion is not merely a result of heat.

Blasting gelatin and gelatin dynamites, on the other hand, are extremely sensitive in a frozen state, which is solely due to the collodion-cotton. In the soft gelatinous state, of course, every shock is annihilated, and the gelatins are in fact indifferent in this state; but when the gelatin is frozen and forms one rigid, hard mass, a blow will be readily communicated throughout the whole mass, and the collodion-cotton will be the first to explode. It is therefore of high importance that the nitroglycerin or dynamite should never be allowed to freeze during manufacture. Even in moderately warm rooms the cold earthenware taps may cause freezing, or drops of nitroglycerin spilt on the floor may become hard, and the danger of working frozen dynamite in cartridge presses is very great. It has repeatedly happened that small crystals of frozen nitroglycerin "cracked" on a wooden floor by being rubbed with a leather shoe.

The sun has a decided effect on the nitroglycerin, inasmuch as the heat generated will decompose it. This is the reason why the roofs and windows should be painted white, especially the window-panes, as they will usually contain some faulty spots which act like lenses. The action of the sun on nitroglycerin that had been inadvertently allowed to run away in the sand has several times produced explosions.

The refuse resulting from the sweepings, the residues on the filters, the mud in the deposit of washings, etc., have to be carefully burned. This refuse, or even defective dynamite, if laid out in a train and ignited, will burn quietly for some time, but then suddenly explode. The author is indebted to Dr. Dupré, F. R. S., for the hint that by pouring paraffin oil over such refuse it can be burnt without fear of explosion.

Although all the possibilities of danger have not been mentioned, and although perhaps the long list may have alarmed you, yet the author confidently asserts, from personal knowledge and long experience, that the manufacture of dynamite is far less dangerous and certainly less subject to sudden and unforeseen accidents than that of gunpowder, which has a record of casualties for more than five centuries.

Smokeless Powder.—The manufacture of smokeless powders has within the last four years come to the foreground, and is in many instances similar to that of the gelatin-compounds. As it is a comparatively new industry, chiefly in the hands of governments, and as none of the powders can yet claim to have reached the stage of perfection, it may seem to be superfluous to enter into many details. The fact that nearly every factory has some process of its own, because every one is anxious to keep his own experiences secret, makes general remarks very difficult.

Smokeless powders are practically of two kinds, those made from gun-cotton and a solvent only, and those made from nitroglycerin and gun-cotton with or without the aid of a solvent. Of late nitrated starch seems to be favored. As a solvent, acetone is now generally used, and the process of dissolving the gun-cotton, or making a gelatin of nitroglycerin and soluble gun-cotton, with or without the subsequent addition of insoluble gun-cotton and camphor, does not want any special allusion, as the machines for incorporating the materials are about the same as now used for the manufacture of blasting gelatin. But the subsequent working up into small square sheets or round disks, in imitation of the manufacture of certain pastries, requires more attention, although it must be said that the acetone, of which traces always remain in the powder, renders it comparatively safe. The jelly-like incorporated mass when leaving the mixing machine is subjected to a partial evaporation, and then passed through steam-heated rollers to be rolled into sheets, and at the same time to evaporate all the acetone. In these rollers small local explosions sometimes take place, which are probably due to some undissolved gun-cotton being submitted to heat and friction, but which pass away without doing any harm. Great care has to be taken to collect the acetone vapors, as they are explosive and may spread over a large area. The cutting of these sheets into small squares is also without special risk, as the pressure on the sheet is small, and no undue friction is likely to occur. Of course the powder should not be allowed to accumulate, as, although considerable quantities of it can burn without explosion, yet the fire spreads quick enough to cut off escape, as has been proved at a fire in an Italian factory. The manufacture of cordite, the British smokeless powder, varies in some stages from that of others, and being the invention of Sir Frederick Abel, and manufactured under his superintendence, does not call for further remark in this paper on the dangers of explosives.

The stability of smokeless powders with regard to atmospheric and climatic influence has still to be conclusively tested.

Other Explosives.—Nitrobenzene is, I believe, no longer used with explosives; its manufacture is well known, and is only dangerous during the nitration and through the poisonous effects of its fumes.

The manufacture of picric acid is also to a certain extent outside the scope of this paper. It presents no danger, during the manufacture proper, but the finished product, when mixed accidentally with certain materials, as lime, nitrate of lead, etc., will produce a detonating mixture, as has been successfully proved by Colonel Majendie and Dr. Dupré in their report about an explosion in Manchester.

Under the name of "Melinite," "Lyddite," "Ecrasite," etc., picric acid has been used for filling shells. Picrate of ammonia, trinitrocresol and the ammonia salt of it are also used. They are melted in a hot water bath and filled into the shells. They are exploded generally by a primer of gun-cotton. As this work is only carried out in military establishments, further consideration is not necessary before this Society. Neither is it necessary to enter into the details of manufacture of roburite, securite, ammonite and similar products, or fireworks. The processes used with the former are very much the same as those used in other manufactories of explosives. In the manufacture of fireworks the preparation of the different mixtures, the compression into rockets, the distribution of pills for amorces, etc., can with little modifications be governed by the considerations applicable to gunpowder factories. Only the frequent use of chlorates, especially Chertier's copper, calls for attention as the cause of many decompositions, and all chlorate mixtures are extremely sensitive to shock and friction. Of course, if the mixture is moistened to form a paste, it will stand a great amount of shock, but when too much water is added, some particles may become exposed to the direct action of the blow.

The last explosive to be mentioned, before discussing the dangers in conveyance and use, is fulminate of mercury, which is used for filling caps and detonators. The manufacture is simple enough, and with ordinary precaution no accident should happen. Of course the ebullition after the addition of alcohol has to be carefully regulated, and attention has to be paid to the way the developing vessels are carried about, the fume-pipes put on, etc.; the nitrous ether formed should also be condensed away from fire. The washing of the fulminate should be well attended to, to avoid decompositions,

and the ready-made fulminate should be stored with not less than 20 per cent. moisture. It is chiefly in the working up of the fulminate where the danger comes in. As to drying it, the ordinary precautions as to heating by a current of air, absence of metal in the room, having hair rugs or india-rubber mats on the floor are sufficient.

The mixing of the fulminate with nitrates, chlorates, ground glass, etc., is perhaps the most dangerous part, as thereby a large amount of friction is produced. The process used at Woolwich is certainly the safest, and will give a better mixture than the usual work with a feather. It consists essentially of a silk bag on which there are diagonally placed india-rubber disks, like a string of pearls. To the bottom of this bag is fastened a thread, which is moved by a lever from behind an iron screen, thereby taking up and throwing down the fulminate between the disks. No explosion has happened at Woolwich since the introduction of this ingenious mechanism some years ago.

The filling of caps with the fulminate is done everywhere by carefully planned machines, which avoid friction and overcharging. The compression of the priming composition is best made in molds attached to separate weighted levers for each cap, so that in spite of the probable inequality of filling, each charge should only receive the same pressure as the other. In some factories the whole press is sheltered by a screen which is automatically closed during the compression, and no composition is allowed to be in the room.

In fulminate factories proper precautions must be taken against any possible friction. These are briefly the use of hair rugs, felt slippers, frequent washing and dusting of floors and rugs, preventives against spilling of material, etc. Like other mercury substances, fulminate is injurious to the body, especially the gums of the teeth, if too much dust is produced and ventilation not efficient.

This is the only country, to the author's knowledge, in which the exclusion of iron from the interior of the buildings, the absence of so much as a few grains of mud or grit on a floor, and in general the cleanliness throughout are rigorously enforced. It certainly made a great stir amongst the manufacturers when the Explosives Act came into operation, but seldom was there on the whole a wiser measure taken. If one remembers that last year only in one gunpowder factory were there fatal accidents, and that the mortality amongst the workmen in explosives factories was not larger than that in all London, you will agree with the author that the Explosives Act was

very beneficial and that the inspectors who carry it out are doing most useful work. It is certainly not the absence of a little grit, because in thousands of cases it will be of no harm, but the general spirit of the order, cleanliness and precaution instilled to the workmen which makes a factory safe.

According to the Explosives Act, every danger building must be provided with an efficient lightning conductor. In spite of the Lightning Rod Conference, in which so many eminent men took part, the question as to what forms an efficient lightning conductor is yet undecided. A lightning conductor is a good and useful instrument on a dwelling-house where an accidental disturbance in the arrangement may not do great harm, but the case is entirely different with a workshop or a magazine for explosives. The thorough and reliable examination of a lightning conductor can only be done by an electrical expert, and in a factory where sometimes 100 of them have to be tested this takes several days. Yet, if a gale is blowing, or the factory is exposed to the influence of sea-atmosphere, the lightning conductor is soon out of order again. Then take the presence of machinery in the buildings, tram-lines, pipe-lines overhead and underground, and you will find that a lightning conductor is not only a very limited preventive, but very often a positive danger. Without further entering into this question, the author thinks that a competent investigation of this subject with reference to explosives factories would be very beneficial.

A great many factories are now lit by electricity. Since this paper was written, special regulations in regard to electric lighting in explosives works have been issued by the Home Office. I do not wish to criticise these regulations, as too short a time has elapsed, and their effect cannot yet be appreciated. I will therefore only give my own experience. It is highly important that suitable lightning conductors should be attached to the circuit. From experience, the author knows of two cases where the lightning struck into the wires, which were carried overhead. The wires should always enter a building from opposite sides, so as to prevent accidental short circuits, and no joint or switch should be allowed inside the building. The lamps should invariably be surrounded by a tightly fitting large glass globe, which allows sufficient radiation of the heat. Although the heat on the outside of the lamp is scarcely larger than 120°, yet, if a lamp be covered with explosive dust and the heat cannot radiate into the open air, there will be such an accumulation of heat that serious accidents

may occur. As to an excess of tension in the current, the best plan is to have an arrangement whereby in case the tension rises over a certain limit the whole of the plant is cut out of circuit. It is by far preferable to have the place in darkness than to see sparks traveling along the wires.

It would be quite possible to write a paper by itself about the dangers in connection with the use of explosives in mines. Miners will frequently insist on treating explosives with the greatest recklessness, and if it were not as a rule accompanied by a loss of life or limbs, I would be able to write quite an amusing paper about the innumerable ways in which the miners handle explosives. Carrying gunpowder in open boxes, with a candle on the hat or in the hand, squeezing detonators with the teeth, charging bore-holes with boring bars, thawing dynamite on a hot stove, or even on an open fire, in a straw hat, are cases that frequently occur. It will still take a long time before anything like proper precaution will be taken everywhere.

The carriage of explosives, whether by road, vessel, or rail, is under ordinary circumstances free from danger. No explosive is licensed which does not in itself present a certain degree of safety, and the packing is so substantial that unless the packages are very roughly handled not even a spilling of explosive is likely to occur. For this reason, in almost every country the carriage of explosives by rail is allowed. Of the more important countries, Great Britain alone makes an exception as regards gun-cotton and dynamite, but why cannot be said. The railways will carry gunpowder, detonators, blasting gelatin and gelatin dynamite, but not gun-cotton and dynamite. Gun-cotton is always sent with from 20 to 30 per cent. moisture, in which state it cannot be exploded by ordinary means. Dynamite is no more dangerous than gelatin dynamite, and in the 20 years during which it has been carried on Austrian railways not a single accident has occurred. Let us hope that here also this obstacle will soon be removed; it injures the railways indirectly more than anybody else, as they are the largest consumers of coal and iron, which cannot be won without the use of explosives.

In discussing this paper Mr. Arnold Philip said that some 18 months previously, in going over a large dynamite works, he had seen a plant employed for the recovery of the acids which had been used in the manufacture of nitroglycerin. This apparatus consisted in part of two scrubber towers, apparently built of flags

of sandstone held together outside by iron tie-rods; inside they contained coke or some other suitable material on which to condense the acid fumes. The waste acids were heated in stills connected with the scrubbers; there was, however, some difficulty in employing this apparatus, for explosions were not infrequent. These explosions were usually slight in character, and chiefly occurred in the scrubbers, but they caused considerable financial loss by the damage which they caused to this part of the plant. All the trouble was due to the minute amount of nitroglycerin which remained in the waste acids even after they had been allowed to stand and settle for a very considerable time. On account of this difficulty there was a natural disinclination on the part of the manufacturers to distil waste acid, and it was not at all an uncommon thing in nitroglycerin factories for tons of it to be thrown away. If, however, these traces of nitroglycerin could be satisfactorily removed, the acids might afterwards be recovered, and a great saving thus introduced. It was possible that this might be done by dissolving out the trace of nitroglycerin by means of paraffin. Of course the strength of the acids in question made it quite impossible to employ either hydrocarbons of the benzene series or ether for this purpose. With regard to the question of lightning conductors, it would be interesting to know whether Mr. Guttmann had had any experience with Prof. Oliver Lodge's method of protecting buildings; this was based on the same principle on which electrometers were sometimes shielded by wire cages. Professor Lodge proposed to cover buildings with what was practically a network of galvanized iron wire. This material was of course far cheaper than copper or any copper alloy, and although not so good a conductor, yet for electric discharges of such high potential as lightning, so long as there was a metallic conductor, it really mattered very little whether it had a high or low conductivity.

Mr. de Mosenthal said that he believed that Dr. Dupré's experiment with the broomstick was correct only so far as chlorate of potash explosives were concerned. Referring to the question of lightning conductors, an explosion due to lightning had occurred quite recently in a manufactory on the Continent, where the rod had been examined by an expert a few days only before the explosion occurred, and was therefore probably in perfect order. In that case the conductor was placed on the earthworks which protected the building, but it was generally supposed that the position of the con-

ductors was immaterial. As Mr. Guttmann had pointed out, very little was known about the subject; and it was to be hoped that the report of a Special Commission which had been at work in Germany for something like two years would throw further light on the subject.

Lieutenant-Colonel Cundill remarked that last year only one fatal accident had occurred due to the manufacture of explosives. He thought that statement spoke volumes for the care exercised by the manufacturers. His department was much indebted to the trade for the way in which any suggestions made by them before the Explosives Act came into force had been carried out. The average number of deaths in England and Wales alone caused by explosions in manufacture in the seven years preceding the introduction of the Act was 39.5; the average was now something under eight for the United Kingdom. In 1890 there were eight deaths, but those were all in one factory; and the accident which caused the one death in 1891 was due to a man hammering a cast-iron die-plate with a steel punch in a building where there was gunpowder, this being a flagrant violation of the statutory rules.

After some observations from Mr. Otto Hehner, Mr. Guttmann in reply said that the suggestion of Mr. Philip to use paraffin for effecting the better separation of nitroglycerin from the waste acids had not, to his knowledge, been tried with nitroglycerin, but it had been tried with picric acid. He knew of a case where it had been used for many years for separating the picric acid, but he had recently seen a sample of a compound which had been found during such separation, which was a dangerous one. He had been asked to make experiments with this substance as an explosive, but it smelt so decidedly acid that he requested that it should be taken back as soon as possible and washed. He had carefully considered Professor Oliver Lodge's system of lightning conductors. The idea, however, was not new. A Belgian (Mr. Melsens) was the first to make lightning conductors in that manner. Professor Zenger, of Prague, had developed it, and it had been extensively tried by the Austrian military authorities. In that country, in the mountain region of the Karst, a thunderstorm occurred nearly every day, and the lightning struck everything above ground. They had a number of exposed forts and military stores there, containing gunpowder, ammunition, ready-made shells, etc., and it was not a pleasant feeling to find these things exposed to such thunderstorms. They had

tried the wire-cage system and it was found to be a very effective protection. Colonel Ph. Hess placed in such a cage one of the bridge detonators employed for military purposes, which are so sensitive that the smallest amount of electricity would fire them, and he could not get an explosion although he applied the sparks of a Wimhurst machine. So far no more had been heard about the practical application of this system. As to Mr. de Mosenthal's observations, he would just mention that the broomstick question had been discussed in that room by Dr. Dupré. If he remembered rightly, it was in connexion with kinetite, an explosive which it had been attempted to introduce in this country. For a long time the English government would not pass it, on the ground that it was not safe. This the agent of the firm who introduced the explosive tried, in that room, to explain was not the case. He remembered reading Dr. Dupré's speech on that occasion, in which he stated that everything in the hands of a man who was willing went all right, but that if any person who was not conversant with the matter struck the substance with a broomstick on a wooden floor it would go off. He believed that any explosive which Dr. Dupré had tested did not fail to explode when struck with a broomstick. Lastly, he would deal with Mr. Hehner's observations. He (Mr. Guttmann) had often discussed the question of glycerin with Mr. Hehner, and he was aware that Mr. Hehner held that a small quantity of chlorine, acid, or aldehydes in glycerin was not very important; yet he believed he expressed the opinion of manufacturers when he stated that they held the opposite view. Mr. Hehner had said that experience was the principal thing to be taken into consideration, and the experience of manufacturers showed that the presence of chlorine developed hyponitric acid, a body the formation of which they desired to avoid as much as possible. The same remarks applied to aldehydes and poly-glycerins. It was probably these constituents that formed the amount of organic matter in the residue. If one per cent. of organic matter was present in the residue, there was sure to be a smaller yield of nitroglycerin and a larger development of nitric peroxide.

In his study of the "Explosive Properties of Trinitrotoluene," C. Hausserman has made various experiments to test the safety and suitability of this body as an explosive, and he states that there are no difficulties and dangers in its manufacture which could hinder it from entering the field with other explosives. In order to test its stability

when kept for some time he exposed portions of this body in the air for several months to varying temperatures (—10° to + 50°), and found that when the trinitrotoluene had been crystallized from alcohol, only a slight surface yellow color was noticed, and no change could be detected in any of its other properties; but when the body had only been freed from acid by washing with water and dilute soda and allowed to stand a short time, traces of acid vapors were frequently detected by the "heat test." Some of the trinitrotoluene was rubbed in an iron mortar, alone and mixed with sand, and no change was observed. On striking it on an anvil, only a very slight decomposition could be detected, and this did not give rise to a report or any appearance of fire. Further experiments showed that trinitrotoluene could not be exploded by flame or by heating in an open vessel in the air. Heated on platinum foil it first melts, then evaporates and catches fire, burning quietly with a very sooty flame. Projected on to a red-hot iron plate it simply burns rapidly. When heated in a test-tube it boils at 300°, and if the heat be continued it froths up and catches fire, leaving a large porous carbonaceous residue. Only when a large mass is rapidly heated in a covered vessel does feeble detonation take place, and this produces very slight effects. Seventy grammes of the powdered substance were placed in a closed cubical zinc case, the sides of which measured 4 cm. This case was placed on a cast-iron plate 2 cm. in thickness, and was fired by a fulminate detonator 35 cm. in length. The explosion was accompanied by a loud report and a distinct, although faint, cloud of smoke. The iron plate was quite destroyed and pieces of it scattered widely. Further experiments showed that it belongs to the class of shattering explosives. A mixture was also made of 1 part of trinitrotoluene and 3½ parts of ammonium nitrate. Comparative experiments showed that this mixture did less mechanical work on explosion than the trinitrotoluene alone, but more than a corresponding mixture of dinitrobenzene and ammonium nitrate. It is pointed out that the manufacture of an explosive by mixing trinitrotoluene and ammonium nitrate does not give rise to injurious fumes, as in the case of dinitrobenzene.—*J. Soc. Chem. Ind.*, **10**, *1028*; 1891.

Berthelot and Matignon (Compt. rend., **113**, *246-249*), in studying the Heats of Combustion and Formation of Nitrobenzenes, have obtained the following results;

	Heat of combustion, constant volume. Cal.	Heat of combustion, constant pressure. Cal.	Formation from elements. Cal.	Formation from nitric acid. Cal.
Orthodinitrobenzene	+704.6	+703.5	+0.5	+58.3
Metadinitrobenzene	+698.1	+697.0	+6.8	+64.8
Paradinitrobenzene	+696.5	+695.4	+8.4	+66.4
Trinitrobenzene (1:3:5)	+665.9	+663.8	+5.5	+90.9
Trinitrobenzene (1:2:4)	+680.6	+678.5	−9.2	+76.2

It is clear that although the values for the various isomerides are very similar, as is usually the case, there are distinct differences, amounting to 1 per cent. in the case of dinitro-derivatives, and to 2 per cent. in the case of trinitro-derivatives. The differences are also distinct in the case of the formation from nitric acid, and the heat developed becomes less the more advanced the substitution.

The heat of formation of a nitro-derivative is always but slightly different from that of the generating hydrocarbon ; and it follows that the oxygen of the nitroxyl group has nearly the same combustible power as if it were in the free state. Since the heat of formation becomes less as nitration advances, it follows that the combustible energy of the oxygen gradually increases. The bearing of this result on the explosibility of nitro-derivatives is obvious.

A. Huber, in studying the Physiological Action of Dinitrobenzene (Virchow's Archiv, **126**, *240–270*), finds that the main effects of dinitrobenzene, as tested on both cold- and warm-blooded animals, are changes in the blood, paralysis and intense dyspnœa. The blood becomes of a dark chocolate color; the red corpuscles are largely deprived of their pigment, which in frogs partly collects round the nucleus. Spectroscopic investigation showed an absorption band in the red, reminding one of the similar band of acid hæmatin, and of methæmoglobin, but not identical with either. It is spoken of as the dinitrobenzene band, and it is considered that this compound acts in a specific manner on the blood pigment. After large doses, the urine was found to be brown in color, and to contain a strongly reducing substance, and sometimes dinitrobenzene was itself present. The body temperature is lowered. The illness which workers in roburite factories suffer from appears to be caused by dinitrobenzene fumes.

"The Explosive Properties of Ammonium Nitrate" have been examined by C. A. Lobry de Bruyn, and from the results published in *Rec. Trav. Chim.* we extract the following:

Ammonium nitrate is a component of many explosives which are but slightly sensitive to ordinary mechanical shocks, and are difficult of ignition, although by the detonation of small quantities of mercuric fulminate they are rendered explosive. Berthelot (*Abstr. J. Chem. Soc.*, p. 453; 1882) and Thorpe (*Trans. Chem. Soc.*, p. 220; 1889) prove that endothermic combinations decompose explosively under the influences of mercuric fulminate, and it is well known that explosives require a variable initial impulse to cause their decomposition. The author describes the following experiments which were made with shells of 8 cm. caliber, weighing 7 kilos., and capable of holding about 200 grammes of explosive. The force of the explosion was estimated by the number and weight of the collected pieces and the distance to which they were scattered; the difference between this weight and the original weight being reckoned as shell reduced to powder by the explosion. In the case of black gunpowder fired electrically by a platinum thread, 10 pieces were collected whose collective weight was nearly that of the original shell, but, when a fulminate cap was used, 77 pieces whose collective weight was but 3.8 kilos. was obtained. When shells filled with bellite, dynamite, and cotton-powder were exploded by means of 1 gramme of mercuric fulminate, the shells were reduced to powder. One gramme of mercuric fulminate produced no effect on a shell filled with ammonium nitrate, except to evaporate a small amount in the immediate vicinity of the fuse, whilst the screw holding the shell was moved. Three grammes of fulminate caused a low, rumbling explosion, and 62 pieces of shell were collected which weighed 6 kilos. A shell containing 180 grammes of ammonium nitrate and 20 to 30 grammes of bellite (composed of dinitrobenzene 1 part and ammonium nitrate 4 parts) yielded, on explosion by 1 gramme of mercuric fulminate, 230 pieces weighing 2.75 kilos. Hence it appears that ammonium nitrate requires a stronger initial impulse than either dynamite or dry cotton-powder; that its employment, unless it be mixed with charcoal or aromatic nitro-compounds, is negatived on account of its weaker action, although for coal-mining purposes its employment would seem to be advantageous, as but a slight rise in temperature accompanies the explosion.—*J. Chem. Soc. Abstr.*, *683;* 1892.

Among recent works are to be noted "Études de Tactique,"* by General Lazeux, which deals with the consequences of the adoption

* pph. 8vo, 63 pp. L. Baudoin et Cie., Paris, 1890.

of smokeless powder and of rapid-fire, small-caliber guns; "La Fortification Permanente et les Explosifs en 1890–1891,"* by Capitaine G. de' S., which treats of the effects of nitro-substitution explosives in shell on fortifications, giving the results of experimental trials; "Die gepresste Schiesswolle,"† by Franz Plach, which is an excellent brochure on the properties, preparation and methods of using military gun-cotton for torpedo work, and is especially novel in its illustrated description of the means of forming charges for the heads of auto-mobile torpedoes from service blocks; "Blasting,"‡ by Oscar Guttmann, which devotes some 60 pages to the properties of modern explosives and contains descriptions of a new apparatus for testing the force of explosives; "Miner's Pocketbook,"§ by C. G. Warnford Lock, which gives some useful information on explosives for mining; and "Machines pour fabriquer la poudre," || which is a trade catalogue.

* pph. 8vo, 63 pp. Henri Charles-Lavauzelle, 1892.

† pph. lg. 8vo, 133 pp. 24 ill. Pola, 1891.

‡ lg. 8vo, 179 pp. 136 ill. Charles Griffin & Co., London, 1892.

§ 472 pp. Spon & Chamberlain, N. Y., 1892.

|| pph. 8vo, 52 pp. 14 ill. Grusonwerk, Magdebourg-Buckau.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NAVAL SIGNALING.*

By A. P. NIBLACK, Lieutenant, Junior Grade, U. S. Navy.

DISCUSSION.

Lieutenant S. A. STAUNTON, U. S. Navy.—Mr. Niblack advances many views with regard to signaling in which I heartily concur, and a number to which with equal heartiness I take exception; and as, in a discussion of his paper, it is naturally the criticized views which receive attention, I shall devote my remarks chiefly to the latter class.

The essayist has sent to the Naval Institute several papers on this subject. I have read them all with attention, and I have traced in them a growing tendency to the adoption of certain opinions upon the theory of signaling which are formally set forth in the paper now before us.

It is of advantage to the discussion that the text has appeared, for it gives a definite point upon which to join issue; and I consider the fundamental principles underlying naval signaling to be of great importance. Mr. Niblack says, p. 461: "The writer holds that the Myer code, using with it the four-element numeral code proposed, is the ideal naval signal code, adaptable to all modern conditions; also that the code is of the first importance, and that the means of transmitting it is somewhat secondary."

"Somewhat secondary" is a little undecided; but the tenor of his paper shows plainly that the code employed is, in his opinion, of an importance to which everything else must yield.

This position is, in my opinion, fundamentally unsound. To place the code before the choice of elements and the method of transmitting them, is to place the cart before the horse. My own estimate of the true theory of a system of signals, either day or night, is first to choose suitable elements, and the best method of transmitting them, and then to arrange those elements into the most convenient and suitable code permitted by their number and character. The number and character of elements and their method of transmission are so intimately associated that they cannot well be separated. If the movements of a single flag in the hands of a man are to be the symbols of the elements, their number is best limited to three, as in the Myer system, and their character

* Published in Whole No. 64, Vol. XVIII, No. 4.

to right, left, and front movements. A semaphore arm gives a greater number of distinctly separate and easily recorded positions, and therefore a greater number of elements can be employed. The Very signals again are limited to two elements, because only strongly contrasting colors are admissible in signal lights which are to be read at great distances. The Ardois signals have 62 elements or groups of lights. The number of elements of a flag day system of signals is limited only by the number of flags which, in color and shape, are distinctly recognizable at ordinary distances; and, in practice, the number of elements in a flag code ranges from ten to twenty, besides auxiliaries.

I repeat these well known facts because I wish to call especial attention to the great practical scope of this matter of naval signaling, and to impress upon the members of the Naval Institute my belief that codes must of necessity vary with the signal systems employed.

My experience as flag lieutenant and signal officer of the Squadron of Evolution has taught me the supreme importance of choosing symbols or signal elements that shall be easily distinguished, and of transmitting them with certainty and precision, and with all possible rapidity; and that the code, or arrangement of those elements in combinations to represent numerals, letters, words or sentences, is secondary :—not "somewhat" secondary, but decidedly secondary. This is my text, and it is on this ground that I take issue with the essayist.

Crossing the Atlantic in December, 1889, before the Ardois signals were obtained for any of the new ships, I remember spending half the middle watch one night trying to send a short signal to a ship not a mile away. The ordinary torch, which at that time represented our total achievement in squadron night-signaling, sputtered, threw turpentine, and repeatedly went out after the manner of its kind.

I went back to my berth, chilled, disgusted, and smelling of turpentine; and a few experiences of that kind satisfied me that the "method of transmission" is secondary to *nothing* in a signal system.

I do not find the least objection to Mr. Niblack's preference for the old Myer code over the Continental Morse or the American Morse. But I object to making a fetish of any code, and to the assumption that a system must stand or fall upon the number of its elements and upon the manner in which these elements are combined, which in signal parlance is called its *code*. I do not mean to say that the code is unimportant, but that it is of secondary importance. A careful choice of elements must be made or, under unfavorable circumstances, they cannot with certainty be distinguished from each other. The method of transmission must be satisfactory, or the elements cannot be read at all. Nothing can be sacrificed to these prime requirements. The code comes after them in logical sequence; for the code cannot be utilized—has no value whatever—until the elements employed in it are observed and recorded. The combinations of elements forming a code have no more meaning to a signalman who, through defective choice of elements or defective transmission, has been unable to correctly take in a signal, than would English words written in German or Russian characters have to a school-child.

The Assimilation of Codes.—I quite agree that it is desirable to assimilate the codes of different signal systems, in order to simplify the whole subject and to increase the general knowledge of signaling; but this parallelism should never be carried to a point where it infringes upon more important considerations. The value of a complete assimilation of different codes is largely theoretical; not, in my opinion, amounting to much in practical signaling. The position assumed by Mr. Niblack that every officer and man will thus learn to signal is not sustained by the experience of actual service, in our own navy or in any other. I admit that a great many men and boys may learn to make and to read signals slowly and imperfectly; but only those who stand upon the signal bridge day after day become efficient and are to be trusted. To secure good results it is necessary to make it a vocation on board ship. It is one of the weak points of our service that we have not yet established any signal rates in which men can qualify and re-enlist. The essayist recognizes this deficiency in his paper entitled "The Signal Question up to Date," published in No. 61, Proceedings of the Naval Institute, in which he strongly recommends that signalmen should be rated ranking with coxswains, and paid $30 per month; and that quartermasters be paid $35, and chief quartermasters $50.

Mr. Niblack was instructor in signaling in the Chicago during a great part of the first eighteen months of her cruise, and a very competent and painstaking instructor—thorough in that as in all other professional work; but the boys of his class when first put on the regular signal detail—and the best were always taken—required a good deal of practice at serious and responsible signaling before they became expert and trustworthy.

It is fallacy to assume that all hands in a ship will learn practical signaling; and an argument based upon such assumption is not sound. In the days of the old Myer code only a few people ever really knew how to signal.

Any convenient and rational code is quickly learned by men who constantly use it. The Ardois system has 62 elements or groups of lights. It is not strictly necessary to memorize them, as they are marked on the transmitter and are therefore directly before both the man who is sending and the one who is receiving the signals. But the signalmen soon learned them by simple use and repetition as a child learns the alphabet, and would call them out when displayed without reference to the keyboard.

More than this: ships not supplied with the Ardois were furnished with the description and instructions and were required to take in the Ardois signals with the remainder of the squadron, answering the call and the signal with Very lights; and the elements of the Ardois are so distinct, and their transmission so methodical and excellent, that no difficulty was experienced from the first.

It cannot be too forcibly stated that facility and expertness in the use of any system of signals comes only by habit and practice. A man who receives an hour's theoretical instruction a week, and quarterdeck practice at conversational distance, will halt and bungle with the simplest system; while a man who takes his regular watch on the signal bridge of a ship cruising in squadron

speedily becomes accomplished in the most amplified code. This fact has perhaps failed of its due impression because we have had so little squadron practice; but it is a very real fact. The value of a signal system is not to be determined by theoretical considerations, however pleasing and harmonious, but by its efficiency in practical service. It is a "condition and not a theory" with which we are dealing.

THE ARDOIS SYSTEM OF NIGHT SIGNALS.—The weight of Mr. Niblack's disapproval falls chiefly upon the Ardois. He deals it such blows as the following:

"Why the original Myer code was not used with the Ardois apparatus is difficult to conceive"—p. 451, note.

"The so-called Ardois alphabet violates most of the principles of a good code"—p. 451, note.

"These criticisms are only meant to bring out strongly the important fact that it is not safe to violate the fundamental principles of signaling in the construction of a code"—p. 441.

"An extremely objectionable and unnecessary code"—p. 477.

"Codes that violate every principle of signaling"—p. 478.

And yet with all this reiterated and strenuous abuse of the present Ardois code, the essayist fails to tell us why it is ojectionable and fundamentally wrong. I have looked carefully through his paper and I find therein no reason for condemning the Ardois code except that it cannot be assimilated to the Myer code, which he chooses to establish as a model.

A sketch of the history of the Ardois signal apparatus in our navy will not, I think, be out of place here.

It was introduced into the Squadron of Evolution two years ago. Upon the urgent representations of Rear Admiral Walker, the Chief of the Bureau of Equipment consented to order six sets from Sautté, Harlé and Co., the makers in Paris. In his efforts to obtain this signal, Lieutenant Buckingham and myself, then on Admiral Walker's staff, gave him every assistance in our power, and we were directed by him to present a scheme for marking the keyboard; in other words, to prepare the code. The manufacturers had somewhat modified the original Ardois system, employing all the possible 62 combinations, and arranging them in their present order. It only remained to attribute to the several displays the desired meanings and values.

Each display is an element. The Ardois is a system of 62 elements, and not of *two* elements, although lights of only two colors are employed. The lights of each group are turned on together by a single motion of the transmitter, and are turned off together when answered. With a two-element system, the successive displays of the elements necessary to form a group which represents a letter or a figure require proportional time. It takes four times as long to represent "K," for example, by the Myer code as it does to represent "T." It takes four times as long to burn four Very lights as it does to burn one. This does not obtain with the Ardois groups. It takes no longer to transmit "N" with five lights than it does to transmit "O" with two, or "interval" with one.

Of these 62 elements, 26 were selected for the letters of the alphabet, 10 for numerals, and to others were given auxiliary and conventional significations.

The letters of the alphabet were grouped together and ran consecutively from A to Z on the keyboard, and the numerals were similarly arranged. The construction of the keyboard is such that all groups representing letters have a red light at the top, and all groups representing numerals begin with a white light. Any other 26 elements might have been taken for letters, and any other 10 for numerals. With an abundant number of elements so that each letter and each numeral may be represented by one alone, without necessity for combinations, code formation becomes very simple. When the transmission of these elements is equal in point of time and convenience, it becomes simpler still. I should be very much obliged to any one who would show me scientifically and logically in what single respect the Ardois alphabet "violates the principles of a good code." Mere assertion is not argument and proves nothing.

But Mr. Niblack may ask me: "If you can take any 26 elements for letters, why not take the 26 in which the red and white lights are grouped in the same manner as the right and left motions in the Myer code? You may object to making any sacrifice for code assimilation, but why not take advantage of any benefits it may carry when such assimilation involves no sacrifice?" And anticipating this question, I will answer it later.

The first sets of Ardois received were installed in the vessels of the Squadron of Evolution in February, 1891. The method of installing the lights has been described. The installation of the keyboard is also a matter of importance. The Chicago's keyboard was mounted in a water-tight box on the after bridge, where the operator could see his own lights and those of the other ships—as important a matter in Ardois signaling as in any other. In the Atlanta and Boston the keyboard was placed in the pilothouse, where the operator had a view of his surroundings somewhat more restricted; and in the Yorktown it was at first placed in the conning tower, where the operator could see very little, but was soon shifted to the bridge above. The success of a signal apparatus, as of that of any other mechanism, depends upon proper installation, proper manipulation and proper care. When Admiral Walker took command of the North Atlantic Squadron I found the Philadelphia's Ardois lights mounted upon the main or after mast, and the keyboard under the poop, at least twenty feet from its break. The operator could not see his own lights, nor those of any other ship. Word had to be passed back and forth by one or more men. Some officers with humorous raillery called it the "Arduous Howling System," and the title was a very telling comment upon the method of installation. The *howling* would have been still more *arduous* if the keyboard had been in the dynamo room. Yet, notwithstanding this unfortunate installation with its attendant disadvantages, Admiral Gherardi did not fail to appreciate the great value of the Ardois, and upon taking command of the Special Service Squadron he at once applied for the apparatus for all his ships. He wrote and telegraphed, and offered to delay his sailing, and five sets were sent to him at Panama.

On the 15th of May, 1891, after the signals had been in use for three months and a half, I made to Admiral Walker a detailed report upon them, which report is on file in the Navy Department. Briefly I stated that the Ardois signal was most satisfactory and valuable as a squadron night-signal, especially for tactical purposes. Some of the keyboards had been found to possess slight mechanical defects which subsequent experience has shown, as I stated at the time, to be easily remedied. I thought at one time that it might be necessary to have platinum contacts, or to have an external switch by means of which the current would be turned on after the contacts were made, and turned off again before they were broken; but I am now satisfied that neither modification is necessary. If the bosses are properly aligned, and the pistons are of good shape, there will be no trouble. The first keyboard supplied the Chicago gave a good deal of trouble. A second, substituted for the first at the New York Yard in the fall of 1891, has worked perfectly since that time. The Bennington's keyboard gave trouble a year ago in the South Atlantic, and the difficulty was entirely remedied by slightly flattening the sphero-conical heads of the contact pistons.

The Sellner System.—Mr. Niblack quotes from and criticizes my report of last May, upon the relative merits of the Sellner and Ardois systems.

The object and the circumstances of that trial necessarily made my report a comparison between the two apparatuses. I stated that the Sellner signal worked perfectly well; *i. e.*, worked as it was intended to work; and then I criticized favorably and unfavorably its details, comparing them with parallel details of the Ardois, and discussed to the disadvantage of the Sellner their relative scope. The Sellner purchased by the Department had but 24 elements or displays. 30 displays are possible with four pairs of lights; therefore, of the signal which I reported upon, 20 per cent of its scope was thrown away.

I believe the Sellner apparatus which I tested is the one supplied for ordinary use in the Austrian navy. If that is the case, it is evident that its purpose is simply to employ at night the elements of their day flag system. Our Ardois has a much more extended use, representing not only our signal flags, but also a full alphabet and various conventional signals.

Mr. Niblack quotes some of Lieutenant Sellner's replies to my criticisms. I do not agree with him that lenses are not an advantage. There is no question as to the fact that they strengthen the lights in the horizontal plane, and I hold that under unfavorable circumstances—in snow, or haze, or drifting fog—a stronger light increases the value of the signal. Nor do I think that increasing the difficulty of manipulation is in line with what is generally regarded as mechanical progress. I think it tends rather to distract than to secure the attention of the operator. There is no more danger of making a mistake with the Ardois transmitter than with the Sellner, and it is much easier and more rapid of manipulation.

But these are only mechanical questions. The real question is between five lanterns, or pairs of lights, and four. We could have four lanterns if we chose, and keep all the advantages of the Ardois transmitter and the lenses. Mr. Niblack argues vehemently in favor of four, in order that no display shall

exceed four lights, so that the red and white lights of the groups representing letters may all correspond precisely with the 1s and 2s of the Myer alphabet, and so that the red and white lights of the groups representing numerals may all correspond with the Rs and Gs of the Very numerals. This latter code has been forced upon us by the fact that the system possesses only two elements; and it is part of Mr. Niblack's scheme to impose the same combinations for numerals upon the Myer code, at the risk of delay and confusion. Of the Myer and Very systems I will speak later. Of the Ardois, this scheme cuts off all the displays of five lights, 32 in number, and leaves but 30 displays of one, two, three, and four lights. That is, it proposes, solely for the purpose of code assimilation, to diminish by more than 50 per cent the scope of a valuable night signal.

I have stated my opinion that the practical value of code assimilation is small, and that nothing of any importance should be sacrificed to it. Apart from this there are only three considerations to observe in comparing systems of four and five pairs of lights: first, and by far the most important, their practical value; second, their installation; and third, their cost.

It has already been stated that 30 groups of lights or elements is the maximum with four lanterns, while 62 elements are available with five. Of these 62 elements on the Ardois keyboard, 28 are used for the letters from A to Z and the terminations "tion" and "ing." 10 others are used for numerals, and of the 24 remaining, 20 are used for "interval," "final," "danger," "general," "compass," "tactics," "numeral," "cornet," "cipher," "position," "letters," "understand," "interrogatory," "action," "error," "annul," and "keys" Nos. 1, 2, 3, and 4; and four are vacant and may be assigned uses suggested by future demands. I append a copy of the instructions under which the Ardois has been employed in Admiral Walker's command, which explain the employment of the several introductories and conventional signals. These signals, some of which are of great importance, are not employed for any other purpose. 35 compass signals are superposed upon the displays for letters and numerals, and are controlled by the compass introductory. They are not of great value, as courses are now usually given in degrees, a method for doing which is indicated in the appended instructions; but they are sometimes of service and they produce no confusion.

I am strongly of the opinion that certain displays, which demand instant comprehension and prompt action, should have no secondary significations. It is important that they should each be associated in the minds of officers, quartermasters, and signalmen with but one meaning, and that action should be instant and intuitive, unhampered by any needless mental process or avoidable chance of error. Such a signal is "danger." A reference to our day flag signals will illustrate what I wish to convey.

There is a very conspicuous danger flag which resembles no other flag. When this is shown by a vessel it conveys instantly the idea of dangers to navigation and no other idea. If some other flag of ordinary use—say No. 4 or No. 6 of the code—were employed at some particular place—the foretopsail yardarm, for example—to indicate danger, the information would never be so

prompt, certain and imperative, since there would always remain a mental association with the usual uses of the flag.

In the new colors and patterns for signal flags which I have had the honor to submit recently to Admiral Walker, with an argument for their immediate adoption, and which were presented by him to the Navy Department with a favorable endorsement, I took the red flag out of the code and reserved it for use solely as a powder and warning flag.

Several other displays are of equal or almost equal importance to "danger" in squadron cruising, and should have no secondary meanings. "Hard a starboard" and "hard a port," "stop," and "man overboard" are such. It will be observed that in the instructions these meanings are superposed upon displays employed primarily to represent letters and numerals. This I would change. There are four vacant displays now, and one or two others might be vacated without affecting the value of the system.

One display means "cipher," and there are four "keys." These give great scope and variety in the arrangement and use of secret signals, and in the construction of telegraphic codes.

It is this great scope and flexibility, ample for present and future use, that renders five lanterns more valuable than four. The 30 displays of the latter are nearly all absorbed by the alphabet; numerals, introductories, and conventional signals are of necessity doubled upon displays which have at times another meaning. Of course this is feasible, and it may be done satisfactorily. We may let the meaning of the most urgent and important signal depend upon the introductory which controls it, or upon the conditions of its display, and perhaps avoid misunderstanding and accident. If we were limited to four pairs of lights we should get on quite well. The system would be infinitely superior to anything that we had prior to the introduction of the Ardois. But I think I have shown that five pairs of lights are safer, more convenient, and more valuable, and possess an advantage in practical use which it would be foolish to sacrifice to code assimilation.

The installation is simply a question of height of spars, and presents no difficulty. A distance of 12 feet between the lanterns is sufficient, and this with the present Ardois demands 48 feet between the upper and lower lights. The lower light should be above all the boats, davits and ventilators: that is, from 20 to 40 feet above the water-line according to the class of vessel. This places the top lantern from 68 to 88 feet above the water-line, and if the supporting jackstay be hooked to the end of a monkey gaff (which I advocate), that means a height of truck of say 75 to 95 feet. Such spars can readily be carried by any vessel above the class of torpedo catcher. The topmasts of battle-ships, coast-defense ships, and twin-screw cruisers exist only to display signals, and must be fitted to accommodate those which it has been decided to adopt. To say that the Philadelphia's topmasts are too short to properly install five pairs of lights is to reflect upon the equipment of the ship and not upon the signal. One might as well say that the topmasts of the Portsmouth were not long enough to permit the hoisting of her sails.

I propose that torpedo-boats and torpedo catchers shall carry three pairs of lights.

The cost of five pairs of lights will be about 25 per cent greater than that of four pairs. The Sellner four-lantern apparatus costs in Vienna $486.67. The five-lantern Ardois costs in Paris $775.86. The former is of rather inferior workmanship, and probably labor is cheaper in Vienna than in Paris. I give these figures, which do not include freight, simply to indicate their relative cost. Duties I do not take into account, as they go back to the Treasury. The difference in cost is therefore trifling, and there is nothing in either installation or expense which argues with any force against five lights.

THE PRINCIPLES OF CODE CONSTRUCTION.—Much has been said in the essay under discussion about "ideal codes" and the "principles of codes," but no analysis of the subject has been presented, and no rules have been formulated. I propose to begin with a general principle which I should formulate in about the following language :

Given the number and character of the elements in a signal system, the best code is that by means of which a signal can be transmitted with the least expense of time and labor, while sacrificing nothing of precision and accuracy.

This means that the symbols which are the most easily and rapidly displayed should be employed to represent those numerals or letters which are most frequently used. When a single symbol is used to represent each letter or each numeral, and there is no difference in the displays in point of time or convenience, there is no choice, and the assignment may be made at pleasure. I have pointed out that this is the case with the Ardois. It is also true of the assignment of the day flags to numerals. But when letters and numerals are represented by combinations of symbols successively transmitted, as in the wig-wag system, the case is different, and the smallest groups should be employed to represent the most frequently employed characters.

In the wig-wag system of right and left motions or two elements (the third or front motion being employed only as a division point) there are : 2 groups of 1 element each, 4 groups of 2 elements each, 8 groups of 3 elements each, and 16 groups of 4 elements each.

Fourteen letters of the alphabet can be represented by groups of one, two, and three motions; and the remaining 12 must be represented by groups of four motions.

The employment of the letters of the English alphabet in English composition, including small letters and capitals, is in order and proportion as follows :

e	1520	*d*	590	*b*	272
t	1122	*l*	585	*g*	272
i	1035	*u*	509	*v*	205
a	1015	*c*	485	*k*	130
s	895	*m*	395	*j*	100
n	890	*f*	375	*q*	92
o	890	*w*	332	*x*	82
r	783	*p*	317	*z*	57
h	675	*y*	305	*&*	30

Several of these letters are used in wig-wag signaling as abbreviations of certain words beginning with them, which increases to a slight extent the relative frequency of their employment.

Applying these data, I find that the best wig-wag code would probably be this :—

e, *t*, represented by single motions.

a, *i*, *n*, *r*, represented by groups of two motions.

c, *d*, *h*, *l*, *o*, *s*, *u*, *w*, represented by groups of three motions.

b, *f*, *g*, *j*, *k*, *m*, *p*, *q*, *v*, *x*, *y*, *z*, *&*, represented by groups of four motions.

Although *r* is ranked in alphabetical frequency by *o* and *s*, it is employed in abbreviating *are* and *your*. Similarly *w*, although ranked by *f* and *m*, is employed in two abbreviations.

The Myer and Continental Morse codes are as follows: The American Morse I leave out of consideration ; it is clumsy and unreliable and has no advocates as a wig-wag code.

Myer Code.

i, *t*, represented by single motions.

a, *e*, *n*, *o*, represented by groups of two motions.

c, *d*, *h*, *l*, *r*, *s*, *u*, *y*, represented by groups of three motions.

b, *f*, *g*, *j*, *k*, *m*, *p*, *q*, *v*, *w*, *x*, *z*, *&*, represented by groups of four motions.

Continental Morse Code.

e, *t*, represented by single motions.

a, *i*, *m*, *n*, represented by groups of two motions.

d, *g*, *k*, *o*, *r*, *s*, *u*, *w*, represented by groups of three motions.

b, *c*, *f*, *h*, *j*, *l*, *p*, *q*, *v*, *x*, *y*, *z*, represented by groups of four motions.

The Myer is by far the better of these two, showing indeed but one serious discrepancy, viz., the use of two motions to indicate *e*. The Continental Morse is poor : *g*, *m* and *k* are all clearly out of place, being used with relative infrequency, and, conversely, groups of four motions are improperly assigned to *c*, *h*, and *l*.

I have before me a report of Ensign Lloyd H. Chandler, of the U. S. S. Concord, into whose hands the trial of the "Modified Myer Code," lately sent out by the Navy Department, was placed by Commander White. Mr. Chandler went into his subject carefully, and discussed the results in a most satisfactory manner. He took a number of signals aggregating 853 words, and tabulated the actual number of flag motions required to send these 853 words, excluding "end of words," and taking no account of abbreviations. The result was as follows :—

Myer Code,	9035	flag motions.
Continental Morse Code,	9298	" "
American Morse Code,	9013	" "

The American Morse was 22 less than the Myer. This is accounted for by the fact that in the American Morse code there are three letters, *e*, *l* and *t*, made by *one* flag motion, and that the three letters made by five motions, *p*, *y* and *z*,

are not of frequent use. If in the Myer code the sole change were made of representing *e* by one motion, and *i* by two, there would be saved in the above case 37 motions, and the Myer code motions would be reduced to 8998.

Mr. Chandler then proposed a code by which the same 853 words could be sent by 8781 flag motions. This code only requires the exchanging of *o* with *r* and of *w* with *y* to correspond exactly with the code which I have deduced above from known data ; and, as I have already observed, Mr. Chandler took no account of abbreviations, while I have determined the relative positions of three of these same letters by their employment in abbreviation.

Mr. Chandler further took 600 words from a newspaper paragraph, and tabulating them as before, found that to transmit them required by the

Myer Code,	6926 flag motions.
Continental Morse Code,	7073 " "
American Morse Code,	7075 " "
Proposed Code,	6780 " "

The Myer code is in this case ahead of the Morse, and the proposed code is far superior to either.

To represent numerals by a wig-wag code there are two logical methods. The first is to introduce and end the numerals by a conventional flag motion or group of motions, meaning "numerals follow" or "numerals are finished," and then to employ the simplest combinations of the code, viz., the two of one motion, the four of two motions, and four of three motions for the ten numerals. The second is to employ groups of elements which are not used for letters. This requires us to take groups of five flag motions, and obviates the necessity of an introductory and closing signal. I much prefer the latter as less liable to error. The groups of four, proposed by Mr. Niblack, and recently sent out for trial as part of the "Modified Myer Code," are neither one thing nor the other, and are not logically defensible. Apart from the liability to error which results from duplicating, it takes far more flag motions to transmit numerals than it would if groups of five were employed, since each time numerals are signaled they must be introduced and finished by "num." requiring 10 flag motions. Here we are asked by Mr. Niblack to make a substantial sacrifice in time and certainty, simply that the numerals of the Myer may correspond with those of the Very, two systems absolutely dissimilar in their functions and scope, and in the manner of their use. We are obliged to use groups of four in the Very's signals because bracketing has proved unreliable, and time intervals cannot enter. If we had a third element, say a double star fired from the same cartridge and separating upon explosion, we should go at once to groups of three; and if we had two more elements, we should go to groups of two. Each system of signals should be free to develop and improve within its capacity and the limitations of its use.

To return for a moment to the Ardois. I will now state why the Myer groups representing letters should not be paralleled by the displays of the Ardois.

It would interfere with an arrangement of the keyboard which I think we shall find desirable in the future. It has been the experience abroad, and will

probably be ours, that torpedo-boats can carry only three pairs of lights. This limits them to 14 displays, and to a tactical code. These 14 displays should be given the same meanings on the large keyboard that they bear on the small one, in order that torpedo-boats may communicate with larger vessels as well as with each other.

SHAPES FOR DISTANT SIGNALING.—Experience does not seem to have gone very far in this direction. Shapes to be visible at great distances should be large, and therefore strong and heavy. I think there would be an advantage in employing not less than four—say a globe, cylinder, cone, and inverted cone—in which case there would be 16 groups of two elements; abundant material for a numeral code in groups of two, independent of time intervals and division signals. But this is merely a suggestion.

For squadron signaling at ordinary distances I think flags will always be found preferable—more rapid and less expensive in wear and tear.

CONCLUSIONS.—To recapitulate: In any signal system the determination of the number and character of the elements and the method of their transmission is the primary requisite. As a general rule, it diminishes the labor and shortens the time of signaling, and increases the scope and value of the system, to increase the number of elements; but this should never reach a point which produces confusion; *i. e.*, precision and certainty should never be sacrificed.

The code should then be so constructed as to render the time and labor of signaling as small as possible.

Each system of signals, day or night, squadron or distant, should be that which is best suited to the purposes and conditions of its use; and should be free to develop and improve by the suggestions of experience and the assistance of inventive talent.

Code assimilation is entirely an external bond—an aid to memory—which can only be imposed upon naval signaling to the detriment of essential considerations. No existing system is really complicated. An intelligent apprentice can be taught the rudiments of all of them in a week, and, after that, practice is all that he needs.

Referring to different portions of this paper, I find the following systems, in the light of present knowledge on the subject, entirely suited to naval needs:

Distant Night Signaling.—The Very red and green lights as they now exist, with the groups of four which have been some time in use.

Squadron Night Signaling.—The Ardois in its present shape, subject to change of keyboard if it should be decided to equip torpedo-boats with three pairs of lights. This change of keyboard would require only a change of bosses and of the upper plate.

Day Flag Signaling.—New flags with better patterns and better colors, plates of which have recently been submitted to the Navy Department; and whenever the Department is ready to take up the revision of the Signal Books, an increased number of flags which will permit a better code.

Wig-wag Signaling.—The three elements of right, left, and front, or 1, 2, and 3, and the following code:—

Letters.

a	22	*h*	122	*o*	211	*v*	1222
b	2112	*i*	12	*p*	1212	*w*	111
c	121	*j*	1122	*q*	1211	*x*	2122
d	222	*k*	2121	*r*	21	*y*	1121
e	1	*l*	221	*s*	212	*z*	2222
f	2221	*m*	1221	*t*	2	*&*	1111
g	2211	*n*	11	*u*	112	*tion*	2111
						ing	1112

Numerals.

1	12222	6	22211
2	21111	7	11112
3	11222	8	22221
4	22111	9	11111
5	11122	0	22222

And substantially the abbreviations heretofore used, and such conventional signals as may be deemed necessary.

In distant signaling by shapes the field is open.

I find no more "chaos" or confusion in these several systems with different codes than I do in checking the recoil of a rifle against the shoulder of a man, of a howitzer by a compression slide, and of an eight-inch gun by a hydraulic piston. Each is carefully suited to its uses, is the best product of our present knowledge and experience, and is free to develop upon its own lines.

The revision of our signal books is a pressing need. Upon the direction which this revision takes will depend the character of our day flag system and its code. The work cannot be properly done in an office of the Department, nor is it likely to be done in a squadron, where other demands are always pressing. My belief is that it would be best accomplished by placing it in the hands of a board, and giving that board authority to go to sea at different stages of its work with two ships of the North Atlantic Squadron, to test by exhaustive trial the merits and demerits of its propositions. The work finally concluded, the board should be ordered to report to the Commander-in-chief of the North Atlantic Squadron, and all the tactical and military features of the proposed system should be tested, employing for the purpose as many new ships as could be assembled.

U. S. S. Chicago,
Flagship, Squadron of Evolution,

At Sea { Lat. 24° 34 North.
Long. 81° 16 West.

Order No. 10. *January* 29, 1891.

The following Instructions for using the Ardois Signal System are hereby established for service in this Squadron.

J. G. Walker, *Rear Admiral, U. S. N.,*
Commanding Squadron of Evolution.

The code to be employed will be indicated by the introductory display, as follows:

If "compass" be displayed, the display that follows it will have the signification of the lower line, and will indicate a course to be steered. Sectors 37, 38 and 39 apply quarter or half point corrections to a course previously signaled, or to the one that the Squadron is steering at the time.

"Danger," not followed by a second signal, means danger ahead, and is an emergency warning signal. If the danger is not ahead, "danger" will be followed by a second display, which will be read as if preceded by "compass," and will indicate the bearing of the danger.

"Ahead" in this sense means the direction in which the Squadron is steering.

"Tactics" means that the signal following will be found in the Fleet Drill Book; and "Gen." that it will be found in the General Signal Book. In both cases the signals following are the numerals in the upper line from zero to nine inclusive—sectors 32 to 41; the numeral, sector 48; and the interrogatory, sector 54.

The telegraphic and geographic dictionaries will not be employed, as the spelling of the words is equally rapid and more certain.

"Cipher" will indicate the employment of any prearranged secret code.

"Letters" indicate the employment of the upper line, both letters and figures. In this code "interval" indicates the end of a word. Following the introductory display "letters," numbers, expressed in Arabic notation, are not to be preceded by "numeral," sector 48; but in using the General or Tactical codes, the display "numeral" has the same employment as the numeral pennant in day signaling.

The following displays are made independently without code distinction:

"Yes" and "no," sectors 40 and 41. Care must be taken not to employ these sectors with these meanings in the body of a message, or at any time when controlled by the introductory display of "Gen." "Tactics" or "letters."

"Position" has the same use as the position pennant in the daytime.

"Cornet" is used as a call when the signal is intended for one or more ships only. It may be followed by the ship's number, using the numerals, sectors 32 to 41, or by a designating letter, where such has been assigned.

"Understand" is employed as an answer to "danger," and will be employed in other cases, where a repetition of the display might cause confusion or uncertainty. Its use in each case will be prescribed.

The answer to a display will, except in the special instances where "understand" is employed, be the repetition of that display; and this answer will be made for each display, whatever the code used. The sending ship will keep the lights on until the receiving ships have all shown the same display. This has a double advantage—that of repeating back the signal received, and that of enabling a ship of the Squadron, to which one or more of the Flagship's lights are masked, to take the signal from a repeating—*i. e.* answering—vessel.

The display should be understood by the receiving vessel before it is repeated. If not understood, the "interrogatory" will be displayed.

"Error" indicates that the sending vessel has made a mistake in the last display, and annuls that display.

"Annul" annuls the whole signal back to and including the introductory or call. If the sender wishes to annul only a part of the message, he follows "annul" with a number, made by using the numerals, sectors 32 to 41; and this indicates the number of displays, immediately preceding the display "annul," which are to be annulled.

"Final" completes all general, tactical, and aphabetical signals; but it does not follow compass signals, the "danger" signal, or single displays complete in themselves.

"Action" is the signal of execution for all compass signals, tactical signals, and exercise signals.

"Keys" Nos. 1, 2, 3, and 4, and the blank sectors 43, 44, 45, and 58, are not at present assigned any signification.

Examples: Flagship wishes to signal "send a boat" to Squadron. She displays "Gen." All repeat. She displays sectors 33, 32, 40, 39, in succession, holding the lights on in each display till all the ships have repeated. She then makes "final" and this ends the message. "Action" is not needed here.

Flagship wishes a boat from Yorktown. She displays "cornet," all vessels repeat. She then displays Y, sector 37 (or Yorktown's number if there be no designating letter). Yorktown alone repeats. Flagship then makes "Gen," and goes on as before.

To signal Squadron to steer S. W. ½ S., the Flagship displays "compass." All ships repeat. She then displays sector 22 (S. W. by S.). All repeat. Then sector 38 (½ St'b). All repeat. She then displays "action." All repeat. When "action" is turned off, the Squadron steers the new course.

All courses are magnetic.

To signal courses in degrees, display "compass," then North or South, then in numerals, the number of degrees to the right. For example, to signal N. 30° W.: make "compass," "South," "1," "5," "0," "action."

[Note.—It will be observed that the uses of the numerals in this case, after "annul," and after "cornet," (to make a ship's number), are special, and are not preceded by the regular introductories.]

The following displays, when made independently—*i. e.* not preceded by an introductory, indicate:

Sector 29	The ship showing it will pass through the formation (as for example to gain or regain position). Each ship makes "understand" and guards against collision.
Sector 28	Man overboard from vessel displaying it. Each ship answers by "understand."
Sector 37	Helm hard a starboard.
Sector 6	Helm hard a port.

[Note.—The above two signals are of immediate execution to avoid danger, and are not followed by "action." As soon as they are executed, a compass course should be signaled on which the Squadron will be steadied.]

Sector 25	Stop.

Lieutenant J. B. MURDOCK, U. S. Navy.—While cordially agreeing with the views advanced by Lieut. Niblack, I wish to specially emphasize what appears to me to be the vital point, viz. the necessity of clearing up the muddle into which we have fallen, and the establishment of a simple yet flexible code which will be applicable to all conditions of day and night signaling. Twenty years ago we possessed a simple system, but by the abolition of the Myer code and the substitution of two others successively, and the introduction of the Ardois, we have reached a stage where, as already stated in the discussion, the easiest solution is to "send a boat."

We should have one easily memorized code applicable to all conditions. In choosing this code the simpler it is the better. The plan outlined by Comdr. Chester offers many advantages on account of the large number of signals possible in a three-flag hoist, and if fully developed might be an improvement over any as yet tried. I should recommend the substitution of a flashing white light for the green called for. This plan requires, however, a complete new signal book, and seems to be somewhat outside the limits of the present discussion. As Lieut. Niblack is recommending a simplification of present methods and a return to old and well-tried codes, I heartily concur with him.

Mr. Niblack puts the question in its true light when he says "that it should not be lost sight of that a good code is of the first importance, and the mechanical means of transmitting it is in a sense secondary." So far as electrical signals are concerned, the first point to be considered is the code. That decided upon, the means for transmission can be settled. The only influence the latter should have on the decision is that no code should be adopted which involves complex or objectionable transmission. Our course of action with the Ardois has been exactly the reverse. We chose the transmission, and bought the code with it.

My objections to the Ardois are:

1. It introduces an entirely arbitrary code, too complex to be memorized, and necessitating a complete revision of our signal book, to obtain any advantage from its use.

2. It employs five double lanterns, requiring at least fifty feet hoist. This cannot be obtained on very many of our ships. An attempt was made to install an Ardois set aboard the Miantonomoh, and no place could be found to put the lanterns except on the forestay. The lights were then only six feet apart vertically, and could not be seen from aft. The arrangement was so ridiculous that the lanterns were taken out.

3. The French Ardois set as originally chosen is, in my opinion, mechanically and electrically the worst signal box in use. The objectionable points are:

a. The box is large and clumsy.

b. It is not water-tight.

c. Spring contacts are made by pins against bosses on the rings inside the box. These contacts are bad, and as the bosses deteriorate rapidly, they have to be constantly repaired. Repairs are, moreover, difficult to make.

d. The spark on breaking circuit takes place on the bosses, causing the deterioration referred to.

e. The lettering of the dial is so arranged that one-half of the signals are upside down to the operator.

The above defects will be overcome in some sets now under construction. Many other changes have been made in the lanterns and other features.

I think that no better solution of our night signal question can be adopted than that proposed by Lieut. Niblack. The first question, that of the code, he decides in favor of the Myer, as being one that has been well tried and found to be thoroughly good. The code settled upon, we find that it can be represented by four double lanterns. Next arise the minor and comparatively trifling matters of mechanical detail, construction, etc., most of which have already been settled by the Bureau of Equipment.

In matters of detail there are one or two things that still admit of discussion or experimentation. Experiments at the New York Navy Yard do not indicate that there is any advantage in a focusing lantern. If the loop of the lamp filament is one-eighth of an inch out of focus, there is very much less light given off in a horizontal plane than when an ordinary lamp is used. For this reason the Germans and Austrians discard lenses entirely, using an opal shade on the white lantern and a colored one on the red. It is claimed that the opal covered light is visible a greater distance than similar lanterns would be with clear glass. It would be interesting to have a practical test of the use of the white lights in each lantern, making one fixed and the other flashing. It is doubtful, however, if anything would be gained, as the present lights are visible up to the point where their distance apart causes them to blend, and nothing would be gained in increasing candle power, unless greater intervals can be given as well.

The double lantern, half red and half white, placed on the truck and worked by a key under the Myer code, seems preferable to a single lantern worked on the Morse system, as is common in several European navies. A message signaled by flashes can be read with less liability to error than if transmitted under the intervals necessary in the Morse code.

In search light signaling, also, the Myer code, signaling by short flashes, for the same reason seems preferable to the Morse. Experience gained ashore indicates that even in the clearest weather the search light beam is visible at a great distance, if projected so as to appear high above the observer's head. At sea, the air containing more vapor and clouds and less solid matter, the beam might not be so apparent. The search light cannot be considered as a part of the regular signal system, although its use will, under certain circumstances, greatly increase the distance at which communication is possible.

The Ardois system has been tried for some time in the Squadron of Evolution, and is understood to have worked well. From all that I can gather from officers who have been shipmates with it, its good points are those which are inherent in any decent system of electrical night signals; its defects are its own. Any modification proposed should retain the former and eliminate the latter. The one advantage it possesses over a four-lantern code is that, having 62 combinations, it admits of more rapid signaling than the four-lantern hoist, which has only 30. By a complete revision of the signal book, dividing all

signals under 62 heads, each having 62 subdivisions, it is possible to obtain 3844 one or two display signals. It is opening another serious question when we suggest a new signal book, and the advantage stated is otherwise unobtainable. All signaling in the Squadron of Evolution has been done, I am informed, by using the letters of the code for spelling, and the numbers for the general signal book. Thus used, the apparatus necessitates just as many displays as a four-lantern code would, and all necessity for the fifth lantern is removed.

It may be suggested that a possibility of error is involved in having a signal mean both a letter and a number. This seems improbable, as the first display would indicate the code, whether spelling or general. If spelling a message under the Myer code, numerals introduced into the message would be preceded by "numerals" and followed by "letters," when the spelling was renewed. This involves two extra displays, but, on the other hand, greater rapidity of signaling would be possible from the smaller size of the board and the simpler code.

I understand that it is claimed by officers favoring the Ardois code, that as masts are now intended mainly for signaling purposes, they should be made tall enough to carry whatever number of flags or lanterns may be necessary. I heartily concur in this, but with addition of the words "and no taller." If we can with four lanterns transmit signals with the same accuracy and rapidity as with five, it is certainly inadvisable to add a lot of additional tophamper, merely to carry the extra lantern. In considering the space available, moreover, it should be borne in mind that the lanterns should all be below the military top, on account of interfering with the fire of the machine guns.

As the Miantonomoh could not well carry five lanterns, so the Vesuvius and Cushing may find difficulty with four. The latter, spaced ten feet apart, require about thirty-five feet. For signaling up to a distance of two miles it will probably be sufficient to make the spaces six feet, or a total hoist of twenty-one feet. For signaling at greater distances the upper lantern could, by a simple attachment to the signal box, be arranged so as to signal by the Myer or Very code with red and white flashes, and these signals could probably be read four miles. As under the proposed code any signal can be readily transmitted by one double lantern, it appears to me to be wiser to install only one in torpedo-boats, to save weight and complexity. A torpedo-boat could then easily exchange signals with any vessel having the four-light hoist. It is at once evident that the Myer code is much better adapted for this system than either the Morse or Ardois.

The code calls on page 488 are too complicated for night signaling. A single letter necessitating only one display will do as well, thus:

H. Use fleet drill signals.

U. Use geographical signals.

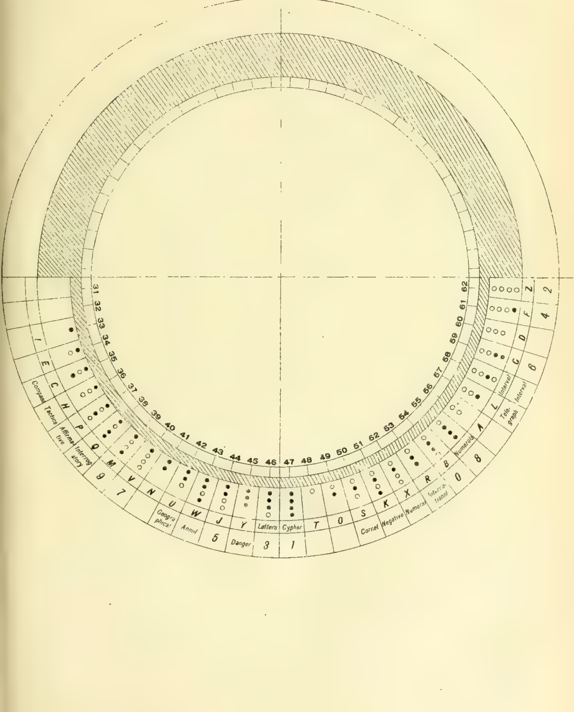
R. Use international signals.

C. Use compass signals.

L. Use telegraph signals.

Letters. Use letters.

All but the latter are three-lantern displays.



31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 62 53 54 55 56 57 58 59 60 61 62
Z F D G L A B R X K S O T
I E C H P Q M V N U W J Y
2 4 6 8 0 1 3 5 7 9
Interval
Tele-graph
Numerals
Internat-tional
Numeral
Negative
Cornet
Cypher
Letters
Danger
Annul
Geogra-phical
Interrog-atory
Affirma-tive
Tactics
Compass

Vessels' numbers could be transmitted under the rules of the Very code.

The first display of a message would designate the code, the second might be a distinguishing letter for a vessel (the above code letters being avoided), or "interval," if the signal is general. The third display would commence the message proper. All signals not specially designated otherwise are general code.

It is impossible to assign a signal for each compass point with the thirty possible combinations. Two methods of compass signaling are possible. One is to designate the cardinal points by their initial letters, N., E., S., and W., in the Myer code, and to signal others by these initials—thus, N. E. N. would signify N. E. by N. Another method would be to mark 28 of the segments with compass points, the cardinal points being designated as above, and the quadrantal points, N. E., S. E., S. W., and N. W. being made by signaling each letter separately.

The criticisms made by Lieutenant Staunton on the Sellner apparatus tested on board the Chicago seem to arise from an impression that the apparatus must be taken as a whole or rejected. This is contrary to our practice thus far in electrical apparatus, the universal custom of the Bureau of Equipment having been to select whatever good features came to its notice and to incorporate them in specifications drawn up to give the service what it needs. No greater mistake can be made than to go into the market and purchase what any inventor thinks will exactly fill service necessities, and yet this is just what has been done with the Ardois "system." The more satisfactory plan is to encourage invention to fill specifications and requirements outlined by officers thoroughly cognizant of the nature of the apparatus needed. If the Myer code can be authorized by the Department, the construction of a signal set conforming thereto is a simple mechanical problem.

A special requirement of night signaling, where each flag of a hoist requires a separate display, is that all important emergency signals should be one, two, or three flag hoists. This will lead to a great saving of time.

The signal sets now in use in the service can be adapted to the Myer code by disconnecting the upper lantern and fitting a new face-plate, as shown in the appended figure. New ones could probably be made semicircular, and of about one-third the size of those in service.

Lieutenant A. P. Niblack, U. S. Navy.—It is very gratifying to have stirred up so much discussion on such an important subject. I have felt that my idea of one code for all purposes was too good to be true; and, if true, too simple to be acceptable. I am now, however, convinced that I have practically the service with me on this subject, and I am glad to say there is some prospect of speedy action being taken by the Navy Department.

My own criticism of my own article on Naval Signaling is that I buried two or three simple propositions under a mass of data about codes and methods in our own and foreign services. I did this trying to be thorough and trying to do justice to all sides. My critics, seeing the situation more clearly and dispassionately, have placed certain issues in new lights. As

Lieutenants Mulligan, Fullam, Bowyer, Mason, and Knapp, and Captain Philip practically side with me on the main issue, I can only express my gratification and pass on with the comment that the New York with truck double lanterns for signaling marks a new era. The millennium will come when we get four lanterns in the Ardois. As Lieutenant Huse rather favors the retention of the American Morse code, I can only beg him to repent while there is yet time. I accept Lieutenant Chambers' modification of my scheme of shapes as a clever and happy solution of the evils resulting from refraction in distorting them at long distances. As to fog-whistle signaling, his method may be better than that in the General Signal Book. In view of his experience, no decision should be made without further trial. Commander Chester very gratifyingly explains briefly and lucidly the scheme of Commander Davis, now awaiting the action of the Chief of the Bureau of Navigation.

Lieutenant Staunton brings out most happily all there is in the real opposition to the adoption of the modified Myer code. Starting from fundamental principles he evolves a new code (practically a modified Myer) which conforms to and confirms the principles I enumerate on page 445. I do not disapprove of the Ardois code simply because it happens to run foul of what I propose as the four-element modified Myer. On page 451 (bottom) I point out that the numeral characters of the Ardois were 1, WR; 2, WRW; 3, WRWR; 5, WRWRR, etc.; and 0, W. This clearly violates Rule 6 on page 445, and Lieutenant Staunton in his new code is careful to have characters for numerals contain the same number of elements. When I say, therefore, that the Ardois numeral code violates *one* of the principles of signaling, I am not unreasonable. As to its violating *all* the principles, I ask Lieutenant Staunton to take the table which he gives of the employment of the English alphabet in English composition in order and proportion, and carefully compare it letter by letter with his Ardois alphabet, and see how the latter ignores every consideration so painfully and elaborately set forth in his own table. I dealt the Ardois alphabet no such blow as this. I simply said, "This code is unfit for any other purpose," which at least allowed the inference that it works well with five lanterns. When its own author gives it the black eye, I can only express my amazement that he does not offer to substitute his theoretically perfect code for this self-condemning Ardois code, thus demonstrating that he is not willing to allow his aversion for assimilation and harmony to go to the extreme of burdening us with an unnecessary code. Fact is, the sentiment of the service is against five lanterns and in favor of four. This is not a rash statement. A five-lantern machine was bought and a code was invented to go with it. Those who were instrumental in getting it of course stand by it. It is out of date in Europe, and we are losing time, money, and dignity in holding on to five lanterns. If we come down to four lanterns, we of course cut off certain special displays, such as "danger," "hard-a-starboard," "stop," "key No. 1," etc. On this point Lieutenant Staunton makes his final stand, saying "I am strongly of the opinion that certain displays, which demand instant comprehension and prompt action, should have no secondary significations. It is important that they should each be associ-

ated in the minds of officers, quartermasters, and signalmen, with but one meaning, and that action should be instant and intuitive, unhampered by any needless mental process or avoidable chance of error. Such a signal is 'danger,' . . . . 'hard-a-starboard,' 'stop,' and 'man overboard.'" Now Lieutenant Staunton spent half the midwatch on the bridge to such good purpose in finding out the worthlessness of the army torch at sea, that, notwithstanding that he returned to his berth chilled, disgusted, and smelling of turpentine, I ask him to persevere in his researches. As a watch-officer I enter my solemn protest against gambling my commission on a signal to vessels astern such as "stop," "danger," "hard-a-starboard," by means of an apparatus with 62 keys, played on by a signal boy at possibly the other end of the ship, when the law of Congress authorizes helm signals with the steam whistle, when we have five speed lights now for no other earthly purpose than to show "stop" or emergency, and when "man overboard" is a Very signal. If we can knock this evil principle on the head by removing one lantern in five, let us continue the good work and come down to three lanterns and do away with speed signals altogether! That "key No. 1" business is the mystery before which we are to bow! *We have no cypher codes*, but with four lanterns it is just as feasible to provide for the future as with five lanterns. As for marring the keyboard or transmitter, the Office of Electric Lighting have a scheme by which, in an hour, they can convert a five-lantern machine into a four, by removing the *top* lantern and use thirty adjoining sectors on the present form of transmitter. It involves no expense, and we are as surely coming to it as that we have arrived at the conclusion that the Ardois code violates the fundamental principles of signaling. Lieutenant Staunton's paper is certainly a most able and valuable one. His arguments against the four-lantern scheme are practically those recently used by the Commander-in-Chief of the North Atlantic Station in a letter of protest to the Secretary of the Navy against any change in the Ardois. The opposition to change rests on broad shoulders, and the two people who are fighting it need no odds in any encounter. I believe, nevertheless, that when the returns come in from the service at large as to the modified Myer code, that it will be elected by a landslide. I have appeared to be trying this signal fight single-handed, but I have felt all along back of me the more or less active approval and sympathy of, not those in high rank, but of the quiet thinkers who leave the rushing into print to younger men like myself, whose enthusiasm for reform has not been as yet chilled by a mature cynicism, and whose impatience with things as they are is only justified by an earnest desire to shoulder the hard work incidental to such proposed reforms.

I thank my critics. I thank the service at large for its patience and long-suffering. I regret not seeing Lieutenant Murdock's paper in time for comment.

PROFESSIONAL NOTES.

REPORT ON THE TEST OF A 14-INCH NICKEL STEEL HARVEYED ARMOR PLATE.

BY ENSIGN R. B. DASHIELL, U. S. N., *Inspector of Ordnance, in Charge of the Naval Proving Ground.*

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NAVAL PROVING GROUND,
INDIAN HEAD, MD., *February* 13, 1893.

THE CHIEF OF THE BUREAU OF ORDNANCE, NAVY DEPARTMENT.

Sir:—I have the honor to submit the following report of the test of a nickel steel Harveyed plate. The firing took place on the 11th instant in the presence of the Chief of the Bureau. The gun used was 10-inch B. L. R. No. 10. The projectiles were all Holtzer armor-piercing shell, weighing 500 pounds each. The weather was fair, the temperature being about 42°–45° F. The plate was secured by 16 bolts of the 2.8″ pattern to an oak backing 8′ high by 10′ wide. The bottom of the plate rested on a string-piece of oak, which in turn was supported by a solid foundation of heavy oak timbers 2′ deep in the ground, and extending more than the full length of the plate. This backing was held against the oak backing already in place on the target structure by 13 iron bolts 1⅜″ diameter, a space of 1′ being left between the two backings for access to the nuts of the armor bolts. The backings were kept apart by 16 cubes of oak 12″ on edge, with the grain running in the direction of the line of fire. The standard rubber washers and cups were used on the ends of the armor bolts under the nuts, and all nuts were set up as hard as possible. The entire installation of the plate was as solid and substantial as could be desired. The distance from the muzzle of the gun to the face of the plate was 385 feet, and the face of the plate was normal to the line of fire when directed at its center.

ROUND 1.—Striking velocity, 1472 f-s. Projectile, Holtzer A. P. shell No. 10. The point of impact was 38″ from the right edge and 32″ from the bottom of the plate. The projectile smashed on the face of the plate, the point and a small portion of the ogival remaining welded in the impact. The rest of the projectile broke up into small fragments, which flew to the sides and rear several hundred feet. Much of the projectile was delivered radially as mitraille over the surface of the plate. These pieces cut off almost the whole of the front and exposed edge of the timber upon which the plate rested. The estimated penetration, judgment being based upon experiences with other Harvey plates in the past, was about 2″. The plate, even in the immediate neighborhood of the point of impact, was quite cool, while the pieces of the shell were very hot. The plate was not cracked, neither was the backing nor structure disturbed by this round. The largest fragment of shell recovered weighed 25 pounds. The face of the plate was not dished at all. . . .

ROUND 2.—Striking velocity, 1859 f-s. Projectile, Holtzer A. P. shell No. 9. The point of impact was 35″ from the left edge and 33″ from the top of the

plate. The shell broke up, leaving a part of its head welded into the plate. The surface of the plate was somewhat scaled off to a depth of from ¼″ to ½″ in a rough circle around the impact. A through crack was opened, extending from this shot-hole downward to the left, running to the edge of the plate. On the edge of the plate this crack was opened about 5″. A fine crack, of depth unknown, extended from this shot-hole to the right and downwards, running tangent to the impact of Round 1, and losing itself about 12″ below the latter impact. The structure set back elastically about 1″. The plate was warm close to the shot-hole and the fragments of shell were very hot. The estimated penetration was 5″. The surface of plate was dished about 1″. The largest fragment of shell recovered weighed 63 pounds. . . .

ROUND 3.—Striking velocity, 1959 f-s. Projectile, Holtzer A. P. shell No. 12. The shell struck the plate 34″ from the right-hand edge and 25″ from the top, breaking up, the fragments flying in all directions. Its head, very much upset, remained welded into the plate. The impact showed the same circular scaling as that of Round 2. A through crack .5″ to .7″ wide was opened to the top of the plate. A through crack extended downwards and to the left until it met almost normally the crack between the impacts of Rounds 2 and 1. A fine crack, half way through the plate, extended from impact No. 3 slightly downwards to the right edge of the plate. The crack between impacts Nos. 2 and 1 was widened to ½″ diameter, and was extended to the bottom of the plate. The crack from impact No. 2 to the left edge was widened to about .7″. A fine crack half-way through the plate appeared from impact No. 2, extending vertically upwards to the upper edge. Thin fragments of metal were scaled off the edges of all the wide cracks. The estimated penetration was about 6″. The backing and structure set back about 2″ and recovered 1″. The left vertical timber was split off from the shock, the split passing through the line of bolt-holes. All bolts and fastenings remained intact. The largest fragment of projectile recovered was the base, which was almost entire and, roughly, about 5″ in length, weighing 127 pounds. . . . . . . The plate up to the third round had been an entire mass, resisting with its full weight each one of the three shots. After the third round it was divided into three almost equal fragments. The fourth round was directed at the center of the lower left-hand fragment.

ROUND 4.—Striking velocity, 2059 f-s. Projectile, Holtzer A. P. shell No. 4. The shot struck the plate 23″ from the bottom and 26″ from the left edge, broke up, the head remaining welded into the right-hand portion of the impact, the base and body breaking into small pieces, the largest weighing 75 pounds. The estimated penetration was from 10″ to 11″. Cracks already in the plate were widened out considerably, and the plate was broken into seven fragments, all of which remained on the backing, no bolts having been broken. The piece of plate which received the blow of the projectile was broken into three fragments. Its surface was scaled off considerably around the point of impact. The two left-hand pieces of the piece above and to the left, that is, the upper left-hand corner of the plate, were thrown off to the left, both upwards and downwards; the right-hand and larger piece was slightly displaced to the right and upwards at its right-hand end; the remaining two-thirds of the plate was apparently intact and in its original place on the backing. The backing itself was uninjured except that the great force of the blow actually compressed the timber immediately beneath the piece of plate struck, the compression showing about 1″ at the left hand and only visible part of the backing thus affected. The structure set back bodily about 6″, all the steel channel irons buckled badly, but the wood filling timbers placed side by side with these channel irons gave their full support to the blow. . . .

Regarding the entire plate as the target for the reception of the first three shots, and the lower left-hand fragment as the target for the fourth shot, the following table of data is appended:

	Total Energy.	Energy per Ton of Plate.	Estimated Penetration.
Round 1.	7520.9 ft. tons.	470.5 ft. tons.	2″
" 2.	11995 "	749.7 "	5″
" 3.	13320 "	832.5 "	6″
" 4.	14715 "	3344.3 "	10 to 11″
Total,	47550.9 ft. tons.		

Weight of fragment attacked, 4.4 tons.

The marked difference in the performances of Round 1 and Rounds 2, 3 and 4, and the close resemblance between the last three, would seem to indicate that these differences were due to another cause than the increased velocities alone with which these last shots were fired.

The point of the first shell unquestionably did not penetrate as far as the interior limit of the Harvey hardening. Its effect was confined almost entirely to the hard face of the plate, and nearly all the energy of impact was absorbed in shattering and heating the projectile. The plate close to the point struck was *cold*, while all pieces of projectile were very hot. There were no cracks in the plate, showing an absence of, or a perfect resistance to, wedging effect; and the structure was not disturbed or shaken in any way.

As soon, however, as the velocities were increased to such an extent as to warrant the belief that the point of the projectile got in beyond the interior limit of the hardening, all the impacts, even with differing velocities, show the same general characteristics. A greater per cent. of the energy is absorbed by the plate and structure than in the first round. More of the projectile remained welded into the plate, and the wedging effect of greater penetration became noticeable. The fragments of projectile recovered were larger in size than with the first shot. It is impossible to measure the penetration of the first three rounds. A break in the plate allows a rough estimate to be made of the penetration of the last round. The estimated penetrations are based entirely on opinions formed from my experiences with other Harveyed plates from which the projectiles have been removed, and are by no means absolute.

In forming a correct estimate of the remarkable qualities of this plate it is necessary to consider the results of the test from what might be termed its external and internal aspects—external as regards plate and projectile, internal as regards the ship or structure supporting and protected by the plate.

Considered externally, the plate fulfilled the requirements of the ideal plate —it resisted and broke up four projectiles of standard armor-piercing qualities, fired with velocities varying from those that would obtain at the commencement of an action at moderate range to those that would be reached by a high-power gun at 100 yards or close range. It protected from all injury the backing upon which it was mounted, even under the severe conditions of the last shot, when a fragment less than one-third of the plate was attacked by the heaviest energy employed in the test; and the plate has shown itself more than a match for any 10-inch gun afloat.

Regarding the plate as a protection for a ship, more is to be considered than the mere breaking up of and perfect resistance to all the projectiles fired at it. The question of the absorption of the energy of the blow is the cardinal point in the case. Armor, if made thick enough, can stop any projectile, but the energy, if the projectile is not broken, goes into the plate, thence into the structure in rear, and the shock and racking effects are very serious. In the case of the Harveyed plate, nearly all the energy of the blow went into the projectile in the first round, the percentage becoming less and less, of course, as the velocity increased, but even in the last round a very large part of the energy went towards breaking and heating the projectile. This plate was mounted upon the same structure and with the same structural resistance as the 14″ nickel plate of the Indiana. The weights of plates were 25 tons to 16

tons in favor of the 14″ nickel, and the striking velocity on the latter plate was 1384 f-s., or nearly 100 f-s. less than that of the first round on the Harvey plate.

Yet the heavier plate was on *each* round set back and structure was racked very much more than was the case with the lighter Harvey plate of the same thickness with shots of 1472, 1859 and 1959 f-s.

As was to be expected, the last shot with 2059 f-s. at the 4.4 ton fragment of the Harvey plate racked very severely the backing and structure on that side, but it could have still stood against another round. The difference is due to the distribution of the energy—if into the projectile, the structure or vessel is but little racked; if into the plate, the structure suffers. These features were so clearly shown in this test—more clearly than in any former trial—that I take this opportunity of bringing them prominently to the Bureau's notice, and to respectfully offer the opinion that from a naval point of view the remarkable behavior and condition of the supporting structure are fully as important matter for consideration as their immediate causes, the projectile-breaking qualities of the plate.

Very respectfully, your obedient servant,

R. B. DASHIELL, *Ensign, U. S. Navy,*
Inspector Ordnance in Charge.

A PROPOSED METHOD OF MEASURING THE EXTENSION OF METALS.

By DION WILLIAMS, Naval Cadet, U. S. Navy.

As every kind of metal used in the construction of ships and their armament must be tested under compression and tension, it is highly necessary that there should be some efficient apparatus for measuring and recording the exact effect of the power as it is applied. Several very complicated contrivances have been devised for thus showing the extension of a specimen bar of metal under tension, but where a large number of such specimens must be so tested the use of these complicated machines involves too much time. To replace these methods by one which is simple in design, and which may be quickly and yet accurately applied, is the object of the contrivance here explained. Referring to the diagram, the specimen bar to be put under tension is shown (A) with the registering apparatus clamped to it. It consists of the two clamps (b_1 b_2), to the lower end of which the triangular scale (c) is firmly clamped by a set screw, and the registering apparatus borne by them. On the upper clamp is a vernier (d) fitted to read the divisions of the scale, which may be graduated in any convenient units. This upper clamp is firmly clamped on the specimen bar by a set screw, and through it the scale is allowed to slide as the specimen is extended under tension; on its outer edge it bears a rack (e) which gears into the pinion (f). Now this pinion with its accompanying gearing is held in the frame (g). This frame is attached to the scale by the set screw (h) and does not move as the specimen is extended. On the shaft of the pinion is a worm (j) which gears in the worm wheel (i), the shaft of which bears a small mirror. At a given distance from the mirror is placed a screen (k) with a tangent scale on it, for the given distance. At the zero of this scale is a slit (s), back of which a light is so arranged that the spot of light showing through the slit will strike the mirror, so that the reflected image of the slit will be thrown on the tangent scale. The specimen to be extended is placed in the testing machine. The two clamps are set on the specimen at the distance apart to be used for the calculations, and the frame bearing the mirror is set so that


b_2

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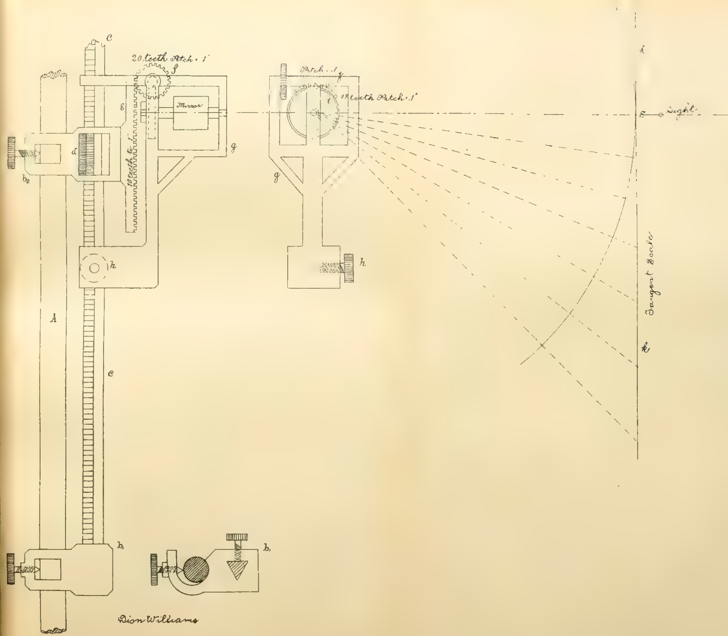

20 teeth Pitch: 1"
Pitch: 1
48 teeth Pitch: 1"
Mirror
10 teeth to 1"
Light
Tangent Scale
A
c
d
e
f
g
h
k
s
t
b_1
b_2
Dion Williams

the pinion (f) is at the top of the rack; and the mirror is set so that the reflected image is at the zero of the vernier. As the tension is put on the bar, the scale and mirror frame being clamped at the fixed end of the specimen, will remain stationary, while the upper clamp (bearing the vernier and rack) being clamped to the movable end of the specimen bar, will move with the specimen as it is extended. By regulating the number of teeth in the rack and gear wheels, the degree of accuracy necessary for the testing of metals to be used for guns and shipbuilding may be arrived at. For instance, if there be ten teeth per inch on the rack, twenty teeth on the pinion (f) with a pitch of one-tenth of an inch, and the worm screw is cut with a pitch of one-tenth of an inch, and the worm wheel (t) have forty-eight teeth, pitch one-tenth of an inch, a tension on the specimen sufficient to give an elongation of one inch will move the mirror through an angle of seven degrees and thirty minutes. If the distance between the clamps, which is the length of the specimen whose extension is measured, be nine inches, an elongation of three inches or about 33 per centum, which is all that would probably occur in practice, would give an angle of 22° 30′. The greater the distance the screen is placed from the mirror the larger will be the distance subtended on the screen by the angle of the mirror. Now if a pressure is put on the specimen, the exact elongation will be known by the movements of the spot of light; in case the pressure be removed, the spot will return to the zero again, if there is no permanent set. If the spot does not return to the zero, then there is a permanent set, shown by the reading of the tangent scale. After the metal has reached the "elastic limit"; *i. e.* when it will not return to its original condition after a pressure producing the deformation is taken off; any further pressure only increases the deformation more rapidly than before the "elastic limit" was reached. By having an observer at the pressure indicator and one at the tangent scale, taking simultaneous readings, a curve may be constructed with these two readings for ordinates and abscissae respectively. This curve will graphically show the performance of any metal under tension, from the point of rest right up to the point of fracture. In it, as in the usual pressure and elongation curves, the elastic limit will mark the point in the curve where regularity ceases; after this point is reached the curve will not follow any particular law of extension, but will present many irregularities up to the point of fracture, where it will end. By the use of such curves all that is required to be known concerning metals under extension may be readily seen, and, after a little comparison, the correct inferences may be drawn. The means most generally employed at present for measuring the extension of specimens is by the use of a pair of micrometer calipers; but this does not admit of the large number of readings admissible by the proposed method. This device is applicable to any of the numerous extension machines where a specimen in the form of a bar of the metal is employed, as it is all attached to the specimen bar itself and not to the machine. The arrangement shown in the sketch is for a vertical tangent scale; but if it were, for any local or constructional reasons, more convenient to have the scale horizontal, it could easily be so arranged by a slight modification of the gearing in the frame (g). The distance traversed by the spot of light would, of course, depend upon the distance of the screen from the mirror. For instance, suppose this distance be a very convenient one, twenty feet. An elongation of two-tenths of an inch will move the mirror through an angle of one degree and thirty minutes. The angle of reflection will be equal to the angle of incidence, hence the actual angle traversed by the ray of light will be double this, or three degrees.

Therefore the reading of the tangent scale will be 240 inches (distance of scale from mirror) multiplied by tangent of the angle, or $240 \times \tan. 3° = 12.598$. Suppose now that sufficient pressure be added to the specimen bar to increase the elongation the one-hundredth part of an inch. This will increase the angle 9 minutes and the new reading will be $240 \times \tan. 3° 9' = 13.209$; hence the

increase will be .611 inch. This of course could be readily seen on the scale. As the extension increased, the divisions on the scale would be longer for the same angle, and hence the accuracy would be thus increased. The device may have many defects, but it is claimed that it is more accurate than the caliper measurements it is expected to replace, and that it gives a rapid and ready means of showing the conduct of any metal under tension.

The members of the Institute are requested to look over the plans and suggest any means which will improve the effectiveness of the design.

PERFORMANCE CURVES OF WAR VESSELS.

By C. M. McCormick, Ensign, U. S. Navy.

Our war vessels are usually tested for their maximum speed, and this under the most favorable conditions. Afterwards they cruise at speeds regulated by their commanding officers in accordance with the duty they are engaged upon, with a general regard to economy of fuel.

It is of great importance in times of peace to know the economical speed of our war vessels, but of infinitely greater importance for the Navy Department to know just what each vessel is capable of performing under all conditions, in order to lay out a plan of action for war. The factor of time may usually be neglected in considering the question of economical speed, but this cannot be done in war time. Practical questions involving the capability of vessels to perform certain work in a certain time must arise, and this capability should be tabulated for every vessel of the navy.

In order to tabulate this capability it is necessary to consider a great number of factors such as the varied conditions of bottom, draught, trim, different qualities of coal, condition and number of boilers used, fires, whether forced, heavy or light, efficiency of machinery, wind and sea, etc., in all the various speeds at which the vessel may have been driven. These data, for a long cruise such as our war vessels usually make, are in such a shape that it is difficult to tabulate them, and impossible to give always the correct allowances for the various combinations of factors.

On board our vessels, when under way, cards are taken once every 24 hours, whenever practicable; but the speed is not accurately taken at the time, nor is care particularly taken to have the revolutions the same for the hour in which they are taken, or the log read accurately at the beginning and end of the hour. From comparison of cards, particularly those taken under somewhat similar conditions, speed curves may possibly be drawn, but cruise after cruise may be made before sufficient data are obtained to make an accurate speed curve and corresponding curves of I. H. P. and coal consumption.

Should the curves be made for one vessel, it is impossible to determine with accuracy the curves of other vessels varying in design, or even of the same design, by calculation alone.

In order to eliminate as many of the variables as possible, I would suggest that the following tests be made on all vessels, and it will be seen that these tests will cost little or nothing over the running expenses, nor call for elaborate preparations nor measured distances, while at the same time they will give accurate performance curves and a reliable means of estimating the influence the varying factors will have under all cruising conditions, and a means of comparing the efficiencies of different ships with regard to speed, consumption of coal, etc.

At a convenient time while on a cruise, with ordinary weather and moderately smooth sea, full bunkers, clean bottom, and —— tons of stores on board, make a succession of speed tests of two hours each, with 30 minutes interval between each test. Commence the tests with sufficient revolutions to make about six knots; run two hours, observing the indicated horse-power and speed. In the 30 minutes interval between the tests increase the revolutions by 10 in the lower and by 15 in the higher speeds. With propellers of great pitch, smaller numbers than 10 and 15 will have to be taken. Continue the tests of two hours, making in each the observations of speed and I. H. P., until a speed has been reached equal to at least three-fourths of the maximum speed of the vessel.

Make the same series of tests again with fairly clean bottom and normal coal supply. After three or four months cruising, and having a foul bottom, make the series again with the bunkers full, and then again with normal coal supply.

We have given for each test the following data, viz: Tons coal, tons stores, ship's draught, displacement, I. H. P., speed, revolutions, conditions of bottom.

From these draw the curves of performance as shown in the diagram.

I wish to state here that these curves are drawn merely as illustrations. I have not the data for any vessel, nor do I know of their ever having been taken, by which accurate curves under all the conditions may be drawn.

A.

Coal 900 tons.
Bottom clean.
Displacement 5000.
Draught 20′ 6″.
a I. H. P.
a′ Revs.
a″ Coal in tons per 100 miles.

B.

Coal 420 tons.
Bottom fairly clean.
Displacement 4500.
Draught 19′ 6″.
b I. H. P.
b′ Revs.
b″ Coal in tons per 100 miles.

C.

Coal 900 tons.
Bottom foul.
Displacement 5000.
Draught 20′ 6″.
c I. H. P.
c′ Revs.
c″ Coal in tons per 100 miles.

D.

Coal 420 tons.
Bottom foul.
Displacement 4500.
Draught 19′ 6″.
d I. H. P.
d′ Revs.
d″ Coal in tons per 100 miles.

$$\frac{\text{I. H. P.} \times \text{coal per I. H. P. per hr. in lbs.}}{2240 \times \text{speed in knots}} \times 100 = \text{tons coal per 100 miles.}$$

The coal per I. H. P. per hour must be obtained from the data of the cruise, selecting those days in which an even speed has been maintained and consequently an even amount of I. H. P. developed. Care should be taken that the revolutions at the instant of taking the diagrams be the same as the average revolutions maintained for the day.

Theoretically the consumption of coal varies directly as the I. H. P. and is independent of the displacement and condition of bottom. In practice it has been found that it requires more coal per I. H. P. when relatively a great or small I. H. P. is being developed than it does when developing a medium I. H. P., and data obtained by a few months cruising at varying speeds will give the consumption for several different developments of I. H. P., and a curve may be drawn from these.

The results obtained will be, for the purpose of illustration, say—

	I. H. P.	Coal in lbs. per I. H. P. per hr.
Triple expansion engine,	500	2.7
	750	2.4
	1000	2.1
	1250	2.0
	1500	1.9
	2000 } 8000 }	1.8
	9000	1.9
	10,000	2.3

Substituting these values in the formula, we obtain a'', b'', c'', d''.

The ordinates are found in this manner because the time of each test is too short to make observations on the coal consumed, and if the time was made great enough to do so it would take several days to make a set of tests, and in the meantime the displacement would have changed, and in all probability the wind and sea also, thereby vitiating the results, which must be taken under the same conditions or accurate comparisons cannot be obtained.

The coal per I. H. P. should be the total coal used on board per I. H. P., and not that used for driving the main engines exclusive of that used in distilling, running dynamos, cooking, etc., as is sometimes taken.

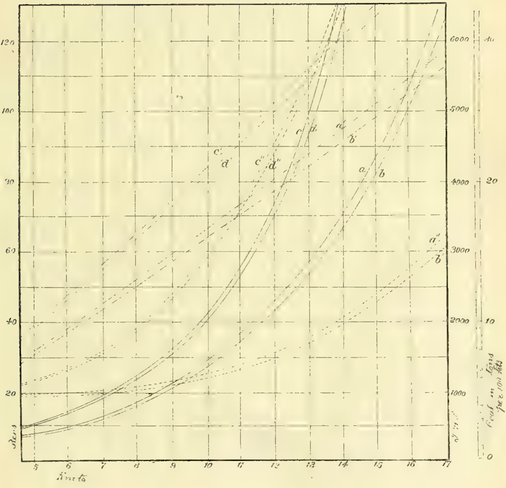
By comparison of I. H. P. developed, and not speed, thereby eliminating a large number of variable factors, it will be much easier to compare the performance of similar boilers and engines, and to find the I. H. P. to develop which it is more economical to use $n+1$ than n boilers.

After the performance curves have been drawn it will be easy to find, by comparison with them and the actual performance, the effect of a strong wind or sea, or both ; a very necessary thing to know when planning certain courses.

Finally, construct a table for each vessel of the navy thus :

Name.	Coal.	Speed.	I. H. P.	No. Days.	Knots.	Coal per Day.	No. Boilers to Use.
U. S. S..........		5					
		5_f					
		6					
		6_f					
		7					
		7_f					
		8					
		8_f					
		9					
		9_f					

etc., where the n_f in the speed column means n knots' speed with foul bottom. I think these tables, while not being absolutely accurate, would be of very great value ; and, as I have shown, they could be made from data collected upon the regular cruising of the vessels, under slight modifications.



120
100
80
60
40
20
6000
5000
4000
3000
2000
1000
20
10
0
5
6
7
8
9
10
11
12
13
14
15
16
17
Knots
c'
d'
c''
d''
c
d
a'
b'
a
b
a''
b''

ELECTRIC BALLOON SIGNALING.

[*Engineering*, February 10, 1893.]

A very interesting paper on this subject was read at a recent meeting of the Royal United Service Institution by Mr. Eric Stuart Bruce. The author has devised a system of signaling with incandescent lamps placed inside a captive balloon, the message being conveyed by means of flashes caused by interrupting the current. The usual drawback of an interrupted current does not appear—at any rate to anything near so great an extent as with naked lights—when the lamps are placed in the semi-translucent envelope of the balloon. The after-glow of the incandescent filament—a phenomenon familiar to any one who has switched off an incandescent lamp—is sufficient to so far obliterate the intervals between the flashes as to render working at a reasonable speed very difficult, if not impossible. The obstruction of the material of which the balloon is composed is sufficient to hide the glow of the carbon; although, of course, a part of the illuminating power of the lamps is lost even when fully glowing, and thus something is detracted from the distance at which the signals can be read. Probably this is more apparent than real. Our own experience is that in reading messages flashed by light, extension of area of the field illuminated largely compensates for loss of intensity. It is desirable not to have the vision too concentrated in reading quickly recurring flashes of light. Of course, in considering this, as in all such matters, the personal factor must not be forgotten; but it is certainly true—at any rate, of some persons—that a faintly luminous body is most apparent when not looked at too directly. Mr. Bruce's system, by which the electric lamps are operated from the ground, so that no person need go up in the balloon, is manifestly an improvement on the plan of using larger balloons and sending up the operators—that is, so far as sending messages at night is concerned; but it must be remembered that a general in the field wants to see as well as to speak, and for this reason the larger balloons are necessary. Again, for day signaling we are not aware that any mechanical device for using semaphores or flags has yet been devised which would be practicable to work from a small balloon. Mr. Bruce has used four different sizes of balloons. The largest has a gas capacity of about 4200 cubic feet and a diameter of 20 feet. The next size will hold 3200 cubic feet, the diameter being 18 feet; the next 2000 cubic feet, diameter 15 feet; whilst the smallest contains 1600 cubic feet, the diameter being 14 feet. For military purposes the largest is preferred by Mr. Bruce, and with pure hydrogen the lifting capacity will be over 1000 feet of electric cable. The smaller sizes, the author says, are more suitable for navy signaling, where reduction of size of balloon is of still greater importance; a statement by no means of universal application, unless it be intended to apply only to the application of Mr. Bruce's system to cases on land where an existing large-size balloon plant is already available. Carriage by sea is generally more easy than carriage by land. Lieutenant Jones, in his instructive lecture read before the Institution in February last—a notice of which appeared in our columns at the time—gave the size of the normal English observation balloon as 10,000 cubic feet. This is smaller than the war balloons of other nations, the French standard size, according to Lieutenant Jones's paper, being 19,000 cubic feet. Mr. Bruce attributes the superiority of our balloons in lifting capacity to be due to the comparative lightness of the material from which the English balloons are made, the precise nature of which is kept secret. Mr. Bruce finds the most suitable material to be a thin cambric, which, when coated with a varnish of a light color, forms an exceedingly translucent medium. In the interior of the balloon, which is filled with pure hydrogen or coal gas, several incandescent electric lamps are placed. These are in metallic circuit with a source of electricity on the ground, where there is an apparatus for making and breaking contact rapidly. To serve the

large observation balloon of 10,000 cubic feet, 84 steel tubes filled with compressed hydrogen are required, each of these being about 8 feet long, 5⅜ in. in diameter, and weighing about 70 lbs. Each of these would contain 120 cubic feet of hydrogen. With the largest of Mr. Bruce's balloons less than half the number of tubes would be required, whilst with the smallest balloon 14 would be sufficient. Mr. Bruce has experienced some trouble in getting lamps with sufficiently fine filaments to fulfil the conditions necessary for high speed in signaling, but this difficulty he anticipates will disappear when the monopoly, due to the existing patents, expires in a few months, and he will then "have an ideal lamp, fulfilling the requisite of fine filament, moderate voltage, and suitable candle-power." The arrangement for suspending the lamps inside the balloon consists of a holder made like a ladder, so that the lamps are placed one above the other, in multiple arc. Six lamps of nominally eight candle-power, but worked much higher, gave signals which were seen at Uxbridge when the balloon was on exhibition at Battersea. The distance is about 16 miles. Experience does not show that the continuous flashing shortens the life of the lamps. The electric cable is made of strands of copper, so as to be very flexible. There is no reason why the holding rope and electric cable should not be all in one, excepting that the latter serves as a guy-rope to keep the balloon steady in case of wind. The first cable weighed 40 lb. per 500 feet of twin cable, but this weight has been reduced to 30 lb. for the same length.

As a source of electric power, Mr. Bruce generally uses storage batteries and when a dynamo is available these answer best. When taking part in the, military tournament at Cork, the cells were charged in London, and when they arrived at Cork they needed no replenishment. They were sent back to London, and were found to be nearly fully charged eight weeks after. The storage battery generally used consists of 25 cells; each cell weighs 24 lb. The size of each cell is 4 in. long and 7⅛ in. wide. Its height is 13½ in. The whole set of 25 cells takes only a space of 3 ft. by 1 ft. 8 in. When a dynamo is not at hand for recharging the cells, it is necessary to have a diminutive engine and dynamo to supply the current; or a small gas engine worked by the hydrogen gas might be used. It is interesting to state that on the occasion of a trial at Chatham by the military authorities, Mr. Bruce's balloon was filled with hydrogen that had actually been used for balloon inflation at Suakim during the Egyptian War, and had been rebottled. . . . . .

The lecturer made some experiments to show that there is no danger from explosion owing to the lamps being immersed in the hydrogen gas. Unless there were a proper mixture of oxygen, there would, of course, be no combustion, and if the hydrogen became diluted to this extent the balloon would no longer float. He also proved by experiment that bullet-holes are not so fatal as would at first be supposed, especially if in the lower part of the balloon, owing to the pressure of the gas being upwards.

The great enemy to the captive balloon is undoubtedly wind, but that, naturally, does not apply to the same extent to balloons which do not carry a car or any living freight. The author says he can do much by a skillful use of guy-ropes, and he made a successful exhibition before the military authorities at Stamford Bridge in half a gale of wind.

There can be little doubt of the immense importance that signaling and observation by captive balloons may have in future warfare. There are many occasions in history when such a means of communication might have turned the fortunes of the day. In this respect, however, we cannot do better than quote Mr. Bruce's concluding words: "It is but a few years ago there was a general shut up with a few followers in a besieged city. Near at hand there were friends to help, but ignorant of the immediate necessity. If from Khartoum there had arisen such an electric signaling balloon as I have described, its flashes of light in the skies would have told the tale of the events below, and perhaps the heroic leader would have left Khartoum a conqueror, with his life spared for the future service of his country that he loved so well."

A NEW PERCUSSION FUZE.

By Henry P. Merriam.

[Reprinted, by permission, from the *Journal of the United States Artillery*, January, 1893.]

The fuze to be described in this article was the outcome of a series of experiments made at the Sandy Hook Proving Grounds during the years 1890–91. It was the purpose of these experiments to produce a base percussion fuze which would be suitable for shells of the larger calibers, and more especially for rifled mortar shells. The chief requirements to be fulfilled were:

1st. Safety, in handling and transportation; 2d. Certainty of action upon concussion on a target; this to mean that a burst should occur whether the shell strikes point foremost or sidewise; 3d. Delay after concussion, to allow time for the shell to penetrate before exploding. . . . .

The fuze as now constructed will be readily understood from the following description and diagram.

Figure 1 shows a longitudinal section of the fuze, showing parts as they exist previous to firing.

Figures 2 and 3 are end elevations.

Figures 4 and 5 are sections along *x-x* and *y-y* respectively, looking in the direction of the arrows.

Figure 6 shows, in separate view, the valve upon which the delay action depends.

Referring to Figure 1. In the fuze case which screws into the base of the shell, the plunger or hammer *A* for exploding the caps is in the form of a sphere. This is held securely in the position shown by the clips *B*, *B*, which abut at one end against a circular recess in the ball, and at the other end against a shoulder in the fuze case. When, in the discharge of the shell, pressure is applied to the trips *C*, the clips *B*, *B* are forced off from the shoulder in the fuze case and thus free the hammer *A*. A flat spring *D* serves to keep the ball to the rear of the cavity during the flight of the shell.

When the velocity of the shell is suddenly checked upon striking a target, the ball, by its momentum, strikes one or more of the small balls *E*—see also Fig. 4—placed above the fulminate caps *F*, and explodes the latter. The resulting flame escapes through the channels *G*—see also Fig. 5—into the chamber *H*. It is also evident from the arrangement of the ball *A* and its surrounding cavity that should the shell strike squarely on its side, the ball in being thrown to one side of the cavity is forced to move forward and thus explode at least one of the caps. In the chamber *H* is placed the delay mechanism, which consists of a disk *I* of closely pressed powder carried on the front of the valve *J*. This valve is capable of a slight movement in an axial direction. This disk of powder, when compressed between two surfaces and ignited at the edge, burns in successive concentric rings, and it requires an appreciable time for the flame to reach the center; when the disk is not thus compressed the igniting flame reaches the center immediately.

At the instant of impact the sudden stopping of the shell causes both the hammer *A* and the valve *J* to move forward, but the valve *J*, on account of its shorter travel, reaches its seat an instant before the hammer strikes the caps. When the flame from the fulminate caps enters the chamber *H*, the valve *J* is pressed firmly against the front surface, and the flame ignites the edge of the disk of powder through the windows *K*—see Fig. 6. As long as the shell is undergoing retardation, the disk *I* remains forced against the forward face and the flame advances slowly, as before stated; when the shell has passed through or has stopped in the target, this force, due to the momentum of the valve, ceases, and the gas pressure between the two surfaces forces the valve away from the forward face, thus allowing the flame to at once reach the center. A

wisp of dry gun-cotton closing the channels *O* serves to conduct the flame to the powder contained in the radial chambers *L*, and from thence it passes to the bursting charge in the shell; these chambers *L* contain supplemental flashing charges to further ensure the ignition of the bursting charge.

A screw *M*, when screwed down, serves positively to hold back the valve *J*, should it be desired to have the explosion as nearly instantaneous as possible at all times.

The pistons on the trips *C* are rendered gas-tight by means of copper caps, arranged after the usual manner of crusher gauges, and tallow or wax fills the space above these.

When screwed into the shell, leakage of the powder-gas by way of the threads is prevented by a washer at the shoulder *f*, *f*.

The small balls *E* are secured in place by being set in the recesses somewhat deeper than half a diameter; a burr at the edge of the recess then holds them.

The safety of this fuze in handling has been abundantly tested by dropping and throwing about. As for certainty of releasing upon discharge, this is fully secured by the size of the pistons and the fact that there are two; either one releasing being sufficient. Certainty of exploding upon striking is secured by employing three percussion primers instead of one; that three defective caps should happen to be in the same fuze is wellnigh impossible. Finally, the delay mechanism for mortar shells would seem to be all that could be desired. It may be said by way of anticipating a criticism, that the apparent complication is due to a duplication of parts which secures greater certainty of action: over sixty of these fuzes have been fired and not one has failed to act.

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MERRIAM BASE PERCUSSION FUZE.

WITH AUTOMATIC DELAY.

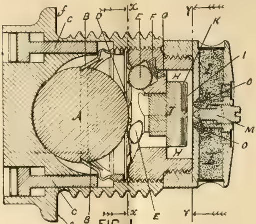

FIG. 1

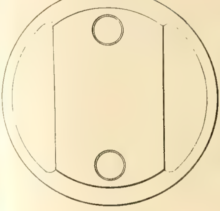

FIG. 2

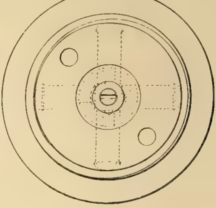

FIG. 3

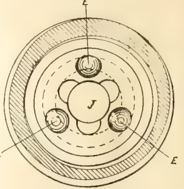

FIG. 4 — SECTION ALONG X X

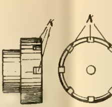

FIG. 6 - VALVE FOR CONTROLLING DELAY

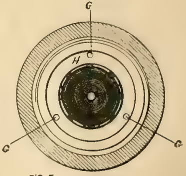

FIG. 5 - SECTION ALONG Y Y

BOOK NOTICES.

The Captain of the Mary Rose; A Tale of To-morrow. By W. Laird Clowes, Member of the U. S. Naval Institute. The Tower Publishing Company, London.

The author of this very interesting book will be remembered by the readers of the Proceedings as the Institute prize essayist for 1892; and he has paid the Institute a graceful compliment by subscribing himself a member on the title-page. The book was no doubt written with an object—to arouse Englishmen to the necessity of being at all times thoroughly prepared in their first line of defense. An affray at Toulon between some English and French sailors precipitates the war necessary for the author's purpose. At first everything goes the way of the French; the English Mediterranean Squadron is soundly whipped by the French fleet, and close upon this disaster comes the destruction of several ships at Spithead by a torpedo-boat flotilla, while Gibraltar is blockaded and bombarded. The hero of the story is a lieutenant, whose name was stricken from the navy list at the beginning of hostilities for indiscretion in sending dispatches to the *Times*. He will not be shelved, however, so he buys an armored cruiser by the aid of wealthy friends, names her after his fiancée, and goes to sea as a free-lance. With his advent comes an entire change of luck. He runs by the French fleet off Gibraltar, sinking or disabling two cruisers and an armored ship, and makes his way to Malta with an important dispatch, stopping *en route* to whip in detail the three fast ships sent in chase. He is permitted to sail with the fleet from Malta and, in the final engagement, which naturally redeems Britain's prestige on the sea, he wins further laurels. The story ends with valor rewarded and domestic bliss assured. Mr. Clowes, although not an officer, has made a serious study of naval matters; and professional men will note with interest his opinions thereon as brought out in the course of his story, and will regret that he has not seen fit to enlighten us as to his views on actions by daylight, as all his engagements take place at night. The illustrations by the Chevalier de Martino and Mr. Jane add much to the general attractiveness of the book.

H. S. K.

Modern Guns and Smokeless Powders. By Arthur Rigg and James Garvie.

This little work of 82 pages is very readable and contains considerable information regarding modern improvements and future possibilities in the development of ordnance and explosives. Technical language is avoided, and the subjects are handled in a manner that renders them easily understood by a layman. A good idea can be obtained of the action of gunpowder in the bore of a gun, and of the effect upon the velocity and pressure of making certain changes in the character of the powder. There is a short description of the principal high explosives and of the machinery used in their manufacture. The peculiarities of these explosives are referred to and their relative advantages for certain purposes are made apparent. The discussion of smokeless pow-

ders is brief, but it is sufficient to give an intelligent idea of the subject and of its effect upon gun construction and modern warfare. As an elementary treatise, aiming at brevity and simplicity, this little book can be well recommended.

W. F. F.

CYCLISTS' DRILL REGULATIONS, UNITED STATES ARMY. By Lieutenant William T. May, M. A.

CYCLE-INFANTRY DRILL REGULATIONS. By Brigadier-General Albert Ordway.

These two little manuals are interesting, in view of the possible adoption of the bicycle for military purposes. A beginning has already been made, both in this country and abroad, and with the improvement of country roads, the bicycle will no doubt be used extensively in operations of war. The movements in these manuals are very simple and are based upon the new Drill Regulations for Infantry. The work of General Ordway is the more complete of the two and is very well illustrated.

W. F. F.

BIBLIOGRAPHIC NOTES.

AMERICAN.

CASSIER'S MAGAZINE.

VOLUME III., No. 13, NOVEMBER, 1892. The Analysis of Cylinder Deposits. The Life and Inventions of Edison.

No. 14, DECEMBER. The Electric Search Light.

An illustrated popular article.

The Life and Inventions of Edison (continued).

No. 15, JANUARY, 1893. Black Prints.

Notice of an improved process of printing black lines on a white ground.

The Life and Inventions of Edison (continued).

No. 16, FEBRUARY. Mechanical Flight.

An interesting discussion of the question, stating the difficulties that have been overcome and those that remain.

The Life and Inventions of Edison (continued). W. F. W.

ILLUSTRATED ELECTRICAL REVIEW.

VOLUME XXI., No. 17, DECEMBER 17, 1892. Electricity in the Art of War.

The first of a series of papers by Lieut. Parkhurst, U. S. A.

DECEMBER 24. A Compact Marine Installation. Electricity in the Art of War (continued).

DECEMBER 31. Electricity in the Art of War (continued).

JANUARY 7, 1893. Electricity in the Art of War (concluded).

JANUARY 28. An Electric Torpedo Detector.

FEBRUARY 4. A New Submarine Boat. C. M. K.

IRON AGE.

VOLUME L., No. 22, DECEMBER 1, 1892. Pneumatic Pumping Apparatus, I. The Worthington Sectional Water Tube Boiler.

DECEMBER 8. The American Society of Mechanical Engineers; Proceedings of the 13th Annual Meeting. Hollow Shafting in Modern Steamships. The Utilization of Niagara Falls.

Early projects and plans now being developed.

Pneumatic Pumping Apparatus, II.

DECEMBER 15. Telegraphy by Induction.

If a cable is used in the ordinary way to connect a light-ship with the shore, trouble is experienced from the fouling of this cable with those anchoring the ship. To avoid this difficulty, experiments are being made by the authorities of the British Post Office. The attempt is being made to communicate by means of two distinct circuits, one on the light-ship and the other including the shore station, these two circuits to act on each other inductively.

Steamship Efficiency.

A comparison of the efficiency of a number of the fastest mail steamers, considering displacement, speed, and coal consumption.

DECEMBER 29. A French Steamship Mobilization Trial.

An experiment on the Normandie to determine the time required to convert a passenger vessel into an auxiliary cruiser.

VOLUME LI., NO. 2, JANUARY 12, 1893. Liquid Fuel Trials in France.

JANUARY 19. Nickel Steel.

Result of tests of boiler plate steel, with and without nickel, made at the Cleveland Rolling Mill Company's works, the results being increase of limit of elasticity and tensile strength without reduction of ductility when containing about 3 per cent. of nickel.

JANUARY 26. Rudder of the Battleship Oregon. Hardened Copper. The Edwards Valve Gear.

FEBRUARY 2. The Shaw 80-ton Gantry and Transfer Crane.

A description, with illustrations, of a new crane for mounting and dismounting heavy guns at the Sandy Hook proving grounds.

A Danish Naval Trial of Water Tube Boilers.

Details of the successful trial of the cruiser Geiser fitted with Thornycroft boilers.

FEBRUARY 23. The Sellers 40-ton Dock Crane.

Detailed description of the crane now in use at the N. Y. navy yard.

The New Armor Specifications.

The new specifications for the armor required by the Navy Department.

The Trial Trip of the El Rio. The Submarine Cable Systems of the World.

C. M. K.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

VOLUME IV., NO. 4., NOVEMBER, 1892. Speed Trials.

Article discussing the present method of conducting speed trials, and proposing certain improvements.

Coal Endurance and Machinery of the New Cruisers. The Allen Dense-Air Ice Machine. Ships (U. S.).

Under this head are given particulars of the new armored cruiser (No. 3) Brooklyn and the sea-going battleship (No. 1), with notes on the Olympia and Cincinnati just launched.

W. F. W.

JOURNAL OF THE FRANKLIN INSTITUTE.

FEBRUARY, 1893. The Priestman Engine as manufactured in America.

Description and discussion of the American modification of the Priestman petroleum engine. According to the writer, Mr. Coleman Sellers, E. D., this engine has proved very efficient and economical where used to develop small powers, and has the great advantage of not requiring expert attendance.

Manganese Steel. By Henry M. Howe.

This metal exhibits a remarkable combination of hardness and ductility, when made in certain proportions (about 13 per cent of manganese) and water-quenched. The paper compares tensile strength, ductility, and hardness of carbon, nickel, and manganese steels. Test bars of the last named under tensile stress do not "neck" to any great extent, but the reduction of area is well distributed over the bar between the shoulders. The paper is to be continued.

H. S. K.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

VOLUME XIV., NO. 61, JANUARY, 1893. Hot-Air Balloons. The Knapsack. Musketry Training.

Captain Parker, 4th Cavalry, makes a strong plea for thorough musketry training and fire discipline. He points out where the present firing regulations can be improved, especially in the directions of simplicity and greater prominence of skirmish firing, and advocates rapidity of fire, both at the butts and in skirmish firing.

Artillery in Coast Defense. Infantry in Combat (trans.). Aerial Navigation. Military Notes: A New Mannlicher Rifle; Professor Hebler on the Best Form of Bullet.

NO. 62, MARCH. Prize Essay: The Army Organization Best Adapted to a Republican Form of Government. The Evolution of Modern Drill Books. Comment and Criticism: II., Whistler's Graphic Tables of Fire, Jump; III., The Knapsack; IV., Musketry Training and its Value in War; V., Military Specialists. Artillery in Coast Defense. Changes in Military Matters. Letters on Strategy, by Hohenlohe (trans.). Military Notes: Continental Methods of Attack; The Souchier Prism-telemeter; The New German Field Artillery. H. S. K.

JOURNAL OF THE UNITED STATES ARTILLERY.

VOLUME I., NO. 5, OCTOBER, 1892. Krupp *v.* Canet Guns. Schneider & Co. 15-cm. Q. F. Guns. Quick-firing Guns.

The number is an extra one and consists practically of papers on the above subjects, reprinted from the columns of *Engineering*. The first subject is made up of an editorial article in *Engineering*, a paper by a French artillerist, a reply by a German artillerist, and a counter reply by a French artillerist. The whole number is a valuable collation of information about foreign guns.

VOLUME II., NO. 1, JANUARY, 1893. A New Percussion Fuze. Some Applications of Glennon's Velocity and Pressure Formulas. Electricity and the Art of War (discussion continued). The Artillery Fire Game (trans.). H. S. K.

RAILROAD AND ENGINEERING JOURNAL.

VOLUME LXVI., NO. 12, DECEMBER, 1892. The First Light-ship with Electric Lights.

Account of the electric plant of Light-ship No. 51, off Cornfield Point, Long Island Sound.

The New Breech-loading Mortars.

Description of manufacture and design of the 12-inch mortars of cast iron hooped with steel, for 73 of which the Builder's Iron Foundry, Providence, R. I., has a contract.

Recent Patents: Pollock's Water Tube Boiler.

AMERICAN ENGINEER AND RAILROAD JOURNAL. (Title changed to above with beginning of new volume.)

VOLUME LXVII., NO. 1, JANUARY, 1893. The New Mannlicher Rifle.

An automatic repeating rifle.

A Quadruple Expansion Marine Engine.

Illustrated description of engines for the Duke of Westminster.

Home Naval Notes: A Ship with Gasoline Engines.

Auxiliary power applied to a schooner for service among the Pacific islands.

NO. 2, FEBRUARY. Recent Inventions in Armor. The Ochta Armor Trial. The Manufacture of Rifles.

Abstract of paper read by Mr. John Rigby, Superintendent of the Enfield Rifle Factory, before the English Institution of Civil Engineers, describing the manufacture of the Lee-Metford rifle.

Home Naval Notes. C. M. K.

TRANSACTIONS AND PROCEEDINGS OF THE GEOGRAPHICAL SOCIETY OF THE PACIFIC.

VOLUME III., 1892. Recent Visual and Photographic Astronomy. Cable Surveys, by Lieutenant-Commander Z. L. Tanner.

The author gives a résumé of the surveys between California and the Sandwich Islands made by Captain (now Rear-Admiral) Belknap, Comdr. Reiter, and himself. H. S. K.

TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

VOLUME XIII., 1892. XIV. MEETING, NOVEMBER, 1891. Rules of the Society. The Evolution of American Rolling Mills (President's Annual Address). The Brooklyn Pumping Engines of 1860. Electric Power Distribution. Influence of the Steam Jackets of the Pawtucket Pumping Engine. Appendices III. and IV. to the Report of a Committee on Standard Tests and Methods of Testing Materials (trans.).

XV. MEETING, MAY, 1892. A Self-lubricating Fibre Graphite for the Bearings of Machinery.

This material is said to give excellent results when used for bearings and brushes in dynamos and electric motors.

Utilization of the Power o Ocean Waves.

The writer, Mr. Albert W. Stahl, U. S. N., discusses at some length the trochoidal theory of sea-waves, and in conclusion presents a device for utilizing the power of sea-waves, which he believes to be novel in principle, and from which he anticipates more satisfactory results than those hitherto obtained from machines for the same purpose.

On the Elastic Curve and Treatment of Structural Steel. A Novel Fly-wheel.

A description of a fly-wheel designed by Passed Assistant Chas. H. Manning, U. S. N., to replace the fly-wheel of a pair of large Corliss engines belonging to the Amoskeag Manufacturing Company, of Manchester, N. H. In this instance Mr. Manning appears to have added one more to the many engineering successes that have marked his connection with the Amoskeag Co.

J. P. M.

FOREIGN.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

XXTH ANNUAL SERIES, 1892, VOLUME IX. Mona Island, West Indies (chart). Recent Hydrographic Researches in the Black Sea. Three Years of Storm Predictions on the German Coast. A Demand for Observations of Luminous Clouds. Magnetic Observations at the Mouth of the Elbe. Hydrographic Information on the East Coast of Africa from the Red Sea to Suez Canal. Hydrographic Notes on the West Coast of Africa. A Voyage from Sydney to Apia. Notes on the Passages and Harbors on the North Coast of Java. Minor Notices: The Weather on the German Coast for August, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory at Wilhelmshaven in August, 1892.

VOLUME X. Six Voyages of the Bark Eduard. Extracts from a report on a voyage in the tropical part of the Indian Ocean. A review of lectures on Ocean Geography. The Winds at Trieste. Voyage of the German Cruiser Bassard. Voyages in the Gulf of Guinea. Minor Notices: Anchorage at Mona Island; Hurricane at Marseilles; Whaling in the Antarctic; Aerostatic Voyages for Scientific Purposes; The Weather on the German Coast for August, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in September, 1892.

VOLUME XI. Tropical Revolving Storms in the Southern Indian Ocean. The Great Atmospheric Currents. Minor Notices: Storm in the North Atlantic Ocean on the 4th and 5th of October, 1892; Sun Spots observed in the Years 1889–1892; A Fifth Moon of Jupiter; Remarkable Atmospheric Phenomena; Change of Date at Samoa; Drift of the Parts of a Wreck in Contrary Directions; Emma Harbor at Padang, Sumatra; Key Islands; The Weather on the German Coast for October, 1892, with Tables. Tables: Meteoro-

logical and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in October, 1892.

VOLUME XII. The Discovery of America; a Turning-point in the Commerce of the World. The Winds at Trieste (conclusion). The new Harbor of Leixois, near Oporto, Portugal (with plan). Description of the North Coast of Formosa. Tide Signals at Tamsui Bar. Hydrographic Notes on the West Coast of Africa. Notes on the Passage between Chusan and Kinho Island. Hydrographic Notes on the East Coast of Asia. Voyages on the West Coast of Africa. Bottle-post. Minor Notices: Luminous Phenomena of the Heavens; Aurora Australis; Cayman Islands, West Indies; The new Volcanic Island, Falcon I., in the Tonga Group; The Weather on the German Coast in November, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in November, 1892.

XXIST ANNUAL SERIES, 1893, VOLUME I. Sailing Routes in the English Channel. Mean Daily Variation in the Declination at Wilhelmshaven, from 1883–1885. Instructions of the London Board of Trade in Regard to the Inspection of Running Lights. Review of the Weather in Germany in 1892. Weather, Wind, and Currents on the Coast of Venezuela (Harbor of La Guayra), between June 9th and October 9th, 1892. Extracts from the Cruising Report of Captain Nichelson, of the German Bark "Theodore." Voyage from Bremerhaven to Cape St. Lucas; Mazatlan; Wind and Weather on the West Coast of Mexico during the favorable seasons, Winter and Spring; San Pedro and Cuidad de David, Province of Chiriqui, Colombia; Voyage from San Pedro to Falmouth. Minor Notices: Fernando Noronha; History of the Origin of the West Coast of Normandy; The Weather on the German Coast for December, 1892, with Tables. Tables: Meteorological and Magnetic Observations taken at the Imperial Observatory, Wilhelmshaven, in December, 1892; Summary of the Meteorological Observations at Wilhelmshaven in 1892. H. O.

BOLETIN DEL CENTRO NAVAL.

VOLUME X., JUNE, 1892. The National Manufacture of Dynamite.
Describes a new dynamite manufactory.

Modern Constructions: the Cruiser Patagonia.

JULY. The Wreck of the Torpedo-boat Rosales.

OCTOBER. Torpedo-boat Tactics (with plates), from the *Revista General de Marina* (continued, see p. 205). Modern Constructions—Plan of a Rapid Cruiser (continued). Battle-ships of the Most Modern Types; American Compared with European Designs.

NOVEMBER. Torpedo-boat Tactics (ended).

Nearly the whole number is taken up by the plea in favor of a second class sailor belonging to the crew of the cruiser Patagonia, read before a court martial convened on board the same vessel. It is not without interest.

J. L.

THE ENGINEER.

NOVEMBER 18, 1892. The Vickers Harvey Armor Plate. The Argentine Twin-screw Armor-clad Ram Libertad. Stern-wheeler for the French Government. H. M. S. Revenge.

DECEMBER 2. Editorial—The Russian Armor-plate Competition. The Russian Navy—the Ruric.

DECEMBER 9. Breech-loading Rifled Mortars for the U. S. Government.

DECEMBER 16. Notes on Recent Russian Armor-plate Trials.

DECEMBER 23. Editorial—The Auxiliary Fleet of France.

JANUARY 13, 1893. The Gun Trials of the Twin-screw Armor-clad Ram Libertad. H. M. S. Bonaventure. The Howe Court-martial. Stay Tubes in Marine Boilers.

JANUARY 20. The Repair of the Umbria's Screw Shaft. Harvey Plate Trial.

Test of a Harvey nickel steel 6-inch plate on board the Nettle at Portsmouth.

JANUARY 27. The Cunard Company's New Twin-screw Steamship Campania.

FEBRUARY 3. New Canet Guns and Fittings. Velocities with Modern Guns and Explosives.

Letter to the editor from A. Noble, F. R. S.

FEBRUARY 10. Cordite.

Editorial article in which are given the constituents and ballistic qualities of cordite, the new English smokeless explosive for rapid-fire guns.

FEBRUARY 17. The 9 de Julio.

Trial of the protected cruiser built by Armstrong, Mitchell & Co. for the Argentine navy. On the continuous six hours' run under natural draught, the very high average speed of 21.9 knots was made.

The Worthington Patent Marine Feed-water Heater.

C. M. K.

ENGINEERING.

VOLUME LIV., NO. 1402, NOVEMBER 11, 1892. Trial Trips: the Russian Cruiser Rurik. Two New Battleships, the Revenge and Royal Oak. The Treatment of Marine Boilers (concluded).

NOVEMBER 18. H. M. S. Vulcan.

The Vulcan is a torpedo depot ship, and is quite fully described, especially in her peculiar features of 20-ton hydraulic davits for handling her six second class torpedo-boats, her very complete steam repair shops, and her equipment for laying mine fields.

Graving Docks: the Halifax, Cockatoo in N. S. W., and the Alexandra in Belfast. The Argentine Twin-screw Amor-clad Ram Libertad.

DECEMBER 2. The Iron Industry of Spain. The Manufacture of Small Arms.

Description of methods used at the Enfield factory.

DECEMBER 9. Board of Trade Electrical Standards. The Value of the Steam Jacket (2d report).

DECEMBER 16. The Value of the Steam Jacket (continued).

DECEMBER 23. Launches and Trial Trips.

Launch of the Japanese protected cruiser Yoshino, which is expected to attain a speed of nearly 23 knots, and which will be the fastest cruiser afloat, if successful. Trials of H. M. ships Jason and Scylla.

The Utilization of Niagara. The Thornycroft Boiler.

Experiments in Denmark with the cruiser Gaiser.

Armstrong Quick-firing Guns. Shipbuilding and Marine Engineering in 1892. The Value of the Steam Jacket.

DECEMBER 30. Shipbuilding in Scotland and Ireland. Additions to the Navy.

A résumé of the British warships floated in 1892.

Naval Engineers. Butt Connections of the Shell-plating of Large Vessels.

Abstract of a paper contributed to the *Zeitschrift des Vereines Deutscher Ingenieure* by Herr Middendorf.

VOLUME LV., NO. 1410, JANUARY 6, 1893. Boiler Tube Fastenings. The Danish Cruiser Gaiser. Shipbuilding and Marine Engineering in England (N. E. Coast).

JANUARY 13. The Boilers of the Danish Cruiser Gaiser. A Multiple Projectile or Compound Gun.

This is a project for obtaining very high velocities of projectile for the purpose of studying air resistance. It is proposed to fire the ultimate projectile from a gun-barrel which is itself fired as a projectile from a larger gun.

Launches and Trial Trips: trials of the Brilliant and Jason. The Weather of the Year 1892. The Gun Trials of the Libertad. Marine Boiler Furnaces (begun). Heat and Chemical Energy.

JANUARY 20. The French Projects in Northern Syria. The Strength of Torpedo-boats (illus.).

Gives an account of the collision of a Yarrow 80-ton boat, moving at a speed of 18 knots, with a grain barge at anchor. Although the bow was much stove in and the forefoot bent nearly at right angles to the keel, no shifting of machinery nor breaking of steam joints occurred, and the boat returned to port under her own power.

The Three-wire System of Electric Distribution. The Development and Distribution of Power from Central Stations (by Prof. Unwin). Marine Boiler Furnaces (continued). Index to Vol. LIV.

JANUARY 27. Measuring Stellar Photographs. The Proposed Bruges Ship Canal. The Mounting of Navy Guns. The Development and Transmission of Power, etc. (continued). Marine Boiler Furnaces.

FEBRUARY 3. The Edison Triple-expansion Engine and Multipolar Dynamo. H. M. S. Jason. Measurement of Alternating Electric Currents. The Development and Transmission of Power, etc. Screw Propellers. Trials: the Argentine Cruiser Nuovo de Julio.

FEBRUARY 10. Thornycroft's Screw Turbine Propeller.

Description, particularly of means adopted to give backing power.

The Practical Measurement of Alternating Electric Currents. The Development and Transmission of Power, etc. Electric Balloon Signaling. Screw Propellers.

FEBRUARY 17. The Practical Measurement of Alternating Electric Currents (continued). The Development and Transmission of Power, etc. H. M. S. Grafton.

FEBRUARY 24. The Nicaragua Canal. Marine Boilers (editorial). The Mercantile Marine in War. Steam Trials of the 9 de Julio. The Practical Measurement of Alternating Electric Currents (concluded). H. S. K.

HEERES-ZEITUNG.

OCTOBER 1, 1892. Vegetable Diet in Principle and in Practice, Especially in its Bearing upon the Subsistence of an Army.

OCTOBER 5. A French View on Infantry Battle Tactics. The Swiss Army in 1891.

OCTOBER 8. The Swiss Army in 1891.

OCTOBER 15. The Military Budget of Austro-Hungary.

OCTOBER 22. The recent Landing Manœuvres near Cuxhaven, Germany.

NOVEMBER 9. Why Germany must increase her Military Strength.

NOVEMBER 16. French Battle Tactics.

NOVEMBER 23. The French Military Budget for 1893. The Reserves in the French Manœuvres of 1892.

NOVEMBER 26. The Military School at St. Cyr. French Battle Tactics (conclusion).

NOVEMBER 30. Outline of the Military Bills of Germany.

DECEMBER 3, 7 and 14. The Civil War in Chili.

DECEMBER 17. Auxiliary Cruisers.

A criticism of their use in war, and of the manner of arming them.

FEBRUARY 4, 1893. The debate on the German Navy before the Budget Commission. Submarine Boats.

A criticism on the advance made in their construction, and their usefulness.

FEBRUARY 8. England's Position in the Mediterranean.

FEBRUARY 15. A Frenchman's Criticism of the recent Grand Manœuvres of the French Army. H. O.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXVI., NO. 177, NOVEMBER, 1892. The Russian Navy (trans.). Regulations for Mobilization for Home Defense, Regular Forces.

No. 178, December. The Strategic Position in the Mediterranean (trans.). The Magazine Rifle Question (trans.).

A short paper full of valuable statistics.

A short account of the French Marine Infantry.

Volume XXXVII., No. 179, January, 1893. Ventilation of Ships.

This question, which is still several removes from final solution, is presented by Capt. MacIlwaine, R. N., who believes in the system by which foul air is exhausted. In this he is supported in the discussion. The matter of providing fresh-air inlets when natural openings are closed is touched upon, but not in a very satisfactory way.

H. S. K.

MILITÄR WOCHENBLATT.

October 8, 1892. Tests with Aluminium.

October 12. Review of the Latest Military and Technical Discoveries and Inventions.

October 15. Review of the Latest Military and Technical Discoveries and Inventions (conclusion). Increase of the French Navy during the Current Year.

A summary of the vessels in course of construction.

October 19. Review of the Swiss Autumn Manœuvres.

November 2. History of the German War-ships Kronprinz, Friedrich Carl, and Arminius.

A review of the history of these three vessels, which were lately stricken from the German Navy list.

November 5. Why Germany Must Increase her Military Power.

November 9. History of the German War-ships Kronprinz, Friedrich Carl, and Arminius (conclusion).

November 23. The Advantage of Number and Quality in Troops in War.

November 26. The Advantage, etc. (continued). Reorganization in the Russian Army.

November 30. Organization of the Russian Reserves. A New Naval Academy.

A criticism of the Naval War College.

New Guns in Russia.

A brief description of two new guns adopted in the Russian army, one for field artillery and the other for heavy artillery.

December 3. The Recent Law for the Organization of the French Army.

December 7. The Eastern Frontier of France.

December 10. Hardened Nickel-steel Armor.

A brief review of the results of recent armor tests in the United States and England.

DECEMBER 17. Summary of the German Navy List for 1893.

DECEMBER 21. Organization of the French Army for War. Armament of the French Fleet.

A summary of the additions to and changes in the guns of the French navy.

DECEMBER 24. Organization of the French Army for War (conclusion).

JANUARY 2, 1893. Test of the Harvey Armor Plate in Russia. A North American's Criticism of the Recent Ride between Berlin and Vienna.

JANUARY 11. The Grand Artillery Practice at Chalons, and Lessons taught by it.

JANUARY 14. The Present Organization of the French Artillery.

FEBRUARY 8 AND 12. Trial of the 6-cm. Krupp Rapid-fire Gun.

A description of the gun and the result of extended trial of it in 1891 and 1892.

SUPPLEMENT.—NOS. 8 AND 9, 1892. Observations on the Russo-Turkish War of 1877–78, and Contributions to the History of the Same.

NO. 1, 1893. Lecture on the Ride from Berlin to Vienna. The Pursuit from Jena to Prenzlau (a lecture).

NO. 2. Abstract of the History of the Prussian Royal Engineer Commission during the First Twenty-five Years of its Existence.

H. O.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XX., NO. 12. The Relation of the Defensive to the Offensive Naval Power of a State. Rapid-firing Guns of Large Caliber (concluded). The 15-cm. Gun of Schneider & Co.

A complete description of the gun, with an account of its trial, and plate.

The Dimensions of a Modern Man-of-War.

A review of the lecture on this subject delivered by Captain Wilmot, R. N., before the Royal United Service Institution.

German Naval Budget for 1893. Description of the ship San Gabriel in which Vasco de Gama discovered the passage to the East Indies. Armored Ships and Explosives (trans.). Supplementary Remarks on the Destruction of the Blanco Encalada. The English Battleships Revenge and Royal Oak. The United States Cruiser Olympia. The Argentine Armored Ram Libertad. New Designation of Different Degrees of Engine Power Adopted by the British Admiralty (trans.). The Installation of Torpedoes onboard English War Ships (trans.). H. O.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

JULY, 1892. On Shipbuilding in Portsmouth Dockyard; by Mr. White, Director of Naval Construction. On the Applications of

Electricity in the Royal Dockyards and Navy. Description of the Lifting and Hauling Appliances in Portsmouth Dockyard.

This number is the record of the July meeting at Portsmouth, and the three papers mentioned are all of interest to naval readers. Mr. White gives a short history of the yard and an account of past and present constructions. The second paper describes English practice in the installation of electric power for naval purposes in yards and ships. The last paper noted explains the methods used in the Portsmouth yard for transmitting and using power. Steam, hydraulic, and pneumatic power are all in operation, and experience has shown pneumatic superior to hydraulic power in this particular place; the economical ratio is about 13 to 11 in working capstans. It seems rather remarkable that electricity has not been used as a means of transmitting power, especially as there is quite a large electric plant installed in the yard.

H. S. K.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

VOLUME XX., NO. 1, JANUARY, 1893. Defense of a Coast Fortress. Recent Development of Armor and its Attack by Ordnance.

Captain C. Orde Browne, *late* R. A., continues the subject which had been treated in a series of articles terminating in 1887, and brings it up to date. A mass of data is collated concerning armor trials during the past five years, and some deductions drawn therefrom.

NO. 2. Recent Development of Armor, etc. (continued).

Captain Browne continues his subject, and speaks briefly of the use of high explosives, steel armor-piercing common shell, angular impact with A. P. common shell, and woodite, and more at length of Grüson's shielded mountings. This article concludes with a comparison between the perforation formulæ of Fairbairn, Maitland, de Marre, and Krupp, together with some experimental data in test of their accuracy.

H. S. K.

REVUE DU CERCLE MILITAIRE.

OCTOBER 9, 1892. The First Engagements of the Army of the Rhine; from the Notes of an Officer. The New Drill Regulations and Interior Discipline for Italian Infantry.

OCTOBER 16. Drill of the Sanitary Corps attached to the Military Department of Paris. The Divisions of the Reserves at the Manœuvres of 1892. The Ministry of War and the Landwehrs in Austro-Hungary.

OCTOBER 23. The First Engagements of the Army of the Rhine, etc. The Sanitary Corps of the Military Government of Paris.

OCTOBER 30. The Ministry of War and the Landwehrs in Austro-Hungary.

NOVEMBER 13. The Chinese Army of the Green Standard.

NOVEMBER 27. Medical Statistics of the French Army for 1890. Rousseau's Pile and Accumulators (with plates). The Prism-telemeter Souchier.

DECEMBER 11. The Prism-telemeter Souchier (with sketch).

DECEMBER 18. The New Manageable Balloon at Chalais-Mendon.

DECEMBER 25. The Ministry of War and the Landwehrs in Austro-Hungary.

JANUARY 1, 1893. The Military School of Portugal. The New Hebrides Archipelago. The Chinese Army of the Green Standard (continued).

JANUARY 8. Commandant Monteil's Travels in Central Africa.

JANUARY 15. War a Hundred Years Hence. The New Hebrides (ended).

JANUARY 22. The Staff Duties during the Late Military Manœuvres, from the Personal Notes of an English Officer. The Chinese Army of the Green Standard (continued). War a Hundred Years Hence (ended).

JANUARY 29. Field Hospitals. The Combat of Infantry during the Manœuvres of 1892, from the Notes of an English Officer.

FEBRUARY 5. The New Decree concerning Interior Discipline in the Infantry Corps.

FEBRUARY 12. Field Hospitals (with map). The New Decree Concerning Interior Discipline in the Infantry Corps.

FEBRUARY 19. Field Hospitals (with map). The Military Association of Berlin. The New Decree on the Interior Service of the Infantry (ended). J. L.

REVUE MARITIME ET COLONIALE.

DECEMBER, 1892. The Civil War in Chile; Sinking of the Blanco-Encalada by the Torpedo-boats Condell and Lynch.

"This is the first affair in which the Whitehead torpedo manifested its destructive effects in actual warfare, but does not otherwise shed new light on the relative value of torpedo-boats as against armored ships. Circumstances made the task of the Condell and Lynch easy. We may, however, reiterate here what has often been said, and that is, to remain over night at anchor in open roads will be found extremely hazardous; and, if imperative to do so, the commander must protect his vessel with torpedo-nets and send out well organized boat's crews as scouts."

In the Land of the Kanacks (continued). A Study of the Mechanical Theory of Heat. Coal in the Extreme East (Annam, Tonkin, etc.). Historical Studies of the Military Marine of France.

FEBRUARY, 1893. French Interests in Canada. A New System of Compass Cards of Light Weight. In the Land of the Kanacks (continued). The Ancient Troops of the French Navy. The Civil War in Chile (ended). A Study of the Mechanical Theory of Heat (continued). J. L.

RIVISTA MARITTIMA.

JULY AND AUGUST, 1892. First Steps in Nautical Science. Notes on Powders and Explosives (continued).

SEPTEMBER. The Fleet of Discovery (year 1492).

An interesting illustrated article giving many particulars, including the names of the officers and crews of the vessels.

Recent Improvements in Marine Machinery. Notes on Powders and Explosives (continued).

OCTOBER. First Steps in Nautical Science (continued). Notes on Powders and Explosives (continued).

NOVEMBER. First Steps in Nautical Science (continued). Notes on Powders and Explosives (continued). On the Fiske Range Finder.

DECEMBER. Recent Improvements in Marine Machinery (continued from September number). First Steps in Nautical Science (concluded). On the Fiske Range Finder (concluded). On the Use of Electricity for operating Steering Engines from Distant Points and for Indicating the Position of the Helm. Notes on Powders and Explosives (continued).

JANUARY, 1893. The English Naval Manœuvres of 1892. Notes on Powders and Explosives (continued).

FEBRUARY. Torpedo-boats. The Hydrographic Office at Washington and the Pilot Chart of the Atlantic. Recent Improvements in Marine Machinery (continued from December number). Notes on Powders and Explosives. W. F. W.

THE STEAMSHIP.

VOLUME IV., NO. 42, DECEMBER, 1892. The Development of the Machinery of Atlantic Liners. German Feed Heaters and Surface Condensers. The Work and Treatment of Firemen. The Efficiency of Screw Propellers.

JANUARY, 1893. Ice-making and Refrigerating on board Ship. Marine Boiler Furnaces. The Steam Navy of England. A New Lifeboat. European Navies; list of vessels.

FEBRUARY. Marine Boiler Furnaces. Simplex and Huge Torpedoes. Whale-back Steamer for World's Fair Traffic. Arrangement of Cylinders and Cranks in Triple-expansion Engines. Repairing a Propeller Shaft at Sea. H. S. K.

UNITED SERVICE GAZETTE.

JANUARY 14, 1893. The Court-martial on Vice-Admiral Fairfax.

JANUARY 21. Guns on board Ship.

A paper criticising the disposition of the guns on English battleships and comparing them unfavorably with the French.

JANUARY 28. Electric Balloon Signaling. The Next Naval Programme.

FEBRUARY 4. Launch of the Cambrian. Our Naval Supremacy.

FEBRUARY 18. War and the Mercantile Marine.

C. M. K.

LE YACHT.

October 8, 1892. Composition of the French Fleet in European Waters. Trial of a Rapid-fire Canet Gun of 10 cm.

October 15. The French Navy Budget. The Armored Cruiser Latouche Trêville. Launch of the Armored Coastguard Valmy.

October 22. The Torpedo-boat Question in England.

The writer, M. Weyl, comments at some length on the diversity of opinion in England regarding the field for torpedo-boat operations. One party, with Mr. W. Laird Clowes, correspondent of the *Times* at the late manœuvres, as its champion, considers the torpedo-boat an offensive and defensive weapon, capable of making long-distance raids. The other would confine torpedo-boat operations to the vicinity of the shore. The Admiralty meanwhile goes ahead with its construction of 14 sea-going boats of 200 tons and 27 knots, as provided for in the programme of 1892-93.

October 29. The New Organization of the Naval Reserve.

November 5. Mobilization of Auxiliary Cruisers.

November 26. Use of Crude Oil as Fuel in the Navy. The New Yacht Measurement. Melinite Shells.

December 3. The Navy in Dahomey. The Firing on board the Normandie. Guns, Torpedoes and Armor (E. Weyl). The Accident to the Howe.

December 10. Note on the Electric Propulsion of Boats.

December 17. General Assembly of the Union of French Yachts.

December 24. The Institution of Naval Architects and the "Association Technique Maritime."

December 31. The Italian Navy.

This is in substance the history of the rise of the maritime power of Italy.

The Chilian Battleship Capitan Prat.

January 7, 1893. The Navies of the World in 1892. The New Ring-tubes for Boilers in Use on board English War-ships.

January 14. The Navies of the World (ended). "Association Technique Maritime." Determination of the Mechanical Elements of Helicoidal Propellers.

January 21. The Navy Ministerial Changes; Officers' Promotions. The Third-class French Cruiser Troude.

January 28. "The Captain of the Mary Rose," by W. Laird Clowes.

A naval fiction of the same category as the battles of Dorking and Port Saïd.

February 4. The Navy Appropriations in the French Chambers (E. Weyl).

February 11. Diffusion of Light through Water, and its Appliances in the Navy. The Atlantic Flying Division, etc.

February 18. The Navy of the United States (E. Weyl).

February 25. The Establishment of Sailors' Homes in France. Heavy Oils as Fuel on board of Men-of-war.

Very interesting experiments have been going on for some time past in Russia, France, Italy, as well as in the United States, in regard to the use of the residuum of heavy oils for firing purposes, and the results were such that no doubt is left in the minds of experts as to their ultimate adoption on board of a certain class of war-ships. The following are the principal advantages of this method of generating steam: (1) decrease in the number of stokers and coal-heavers; (2) increase of radius of action; (3) absolute absence of smoke with well-regulated fires.

J. L.

EXCHANGES, BOOKS AND PERIODICALS RECEIVED.

American Chemical Journal.

Annual Report of the Commander, First Naval Battalion of the State of New York; 1892.

Annual Report of the Inspector-General to the Secretary of War; 1892.

Bulletin of the American Geographical Society.

Bulletin of the American Iron and Steel Association.

Colliery Engineer.

Engineer, New York.

Engineer-Mechanics.

Geographical Society of California.

Handbook of Military Signaling.

Journal of the Association of Engineering Societies.

Journal of the United States Cavalry Association.

Lend-a-Hand.

Los Orijenes de Nuestra Marina Militar por Luis Uribe Orrego, Contra-Almirante de la Armada. Parte Segunda, 1819–1823; Las Campanas de Lord Cochrane.

Mémoires et Compte Rendu des Travaux de la Société Ingénieurs Civils.

Moniteur de la Flotte.

Norsk Tidsskrift for Sovaesen.

Occasional Papers of the California Academy of Arts and Sciences.

Proceedings of the American Philosophical Society.

Railroad Gazette.

Report of the Superintendent of the U. S. Naval Observatory for the Year ending June 30, 1892.

Revista Maritima Brazileira.

Revista Tecnológico Industrial.

Rivista di Artiglieria e Génio.

Stevens Indicator.

Teknisk Tidskrift.

Tenth Annual Report of the Executive Committee of the Indian Rights Association for the Year ending December 15, 1892.

Tidskrift i Sjöväsendet.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.
TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.
UNITED SERVICE GAZETTE.
UNITED SERVICE.

REVIEWERS AND TRANSLATORS.

Lieut.-Comdr. J. P. MERRELL,
Lieutenant HUGO OSTERHAUS,
Lieutenant W. F. FULLAM,
P. A. Engineer W. F. WORTHINGTON,
Ensign C. M. KNEPPER,
Professor JULES LEROUX,
Lieutenant H. S. KNAPP.

ANNUAL REPORT OF SECRETARY AND TREASURER OF THE U. S. NAVAL INSTITUTE.

To the Officers and Members of the Institute:

Gentlemen:—I have the honor to submit the following report for the year ending December 31, 1892.

Itemized Cash Statement.

Receipts During Year 1892.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Advertisements	$112 50	$308 75	$20 00	$40 00	$481 25
Dues	1099 56	417 00	183 00	247 50	1947 06
Sales	160 30	484 89	79 07	165 80	890 06
Subscriptions	223 15	182 25	145 40	251 70	802 50
Life membership fees	..	30 00	..	..	30 00
Binding	31 25	5 71	2 50	8 25	47 71
Interest on investments	64 71	9 00	45 50	38 00	157 21
Insurance recovered	1000 00	..	..	..	1000 00
Credits on account	20	1 20	10 67	1 71	13 78
Prepayment of expressage and postage	..	..	..	68	68
Profit and loss	..	..	..	3 00	3 00
Totals	$2691 67	$1438 80	$486 14	$756 64	$5373 25

Expenditures During Year 1892.

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Printing publications	$8 90	$652 78	$495 51	$481 00	$1638 19
Advance payment for printing No. 64	..	..	..	200 00	200 00
Binding	24 80	105 00	..	29 93	159 73
Expressage	4 39	6 95	2 65	3 30	17 29
Freight and hauling	65	2 22	2 93	2 35	8 15
Postage	41 25	27 50	28 45	51 36	148 56
Stationery	22 50	8 00	36 25	..	66 75
Telegrams	1 68	70	50	..	2 88
Secretary	90 00	81 00	..	189 00	360 00
Clerk	120 00	130 00	150 00	150 00	550 00
Office expenses	67	..	1 60	8 82	11 09

EXPENDITURES—*continued.*

Items.	First Quarter.	Second Quarter.	Third Quarter.	Fourth Quarter.	Totals.
Expenses, recovery of insurance	$4 70	..	..	..	$4 70
Purchase D. C. Bonds	114 30	..	..	..	114 30
Purchase of back numbers	8 00	3 90	..	..	11 90
Purchase of Postal Guide	2 50	..	..	..	2 50
Subscription Army and Navy Register	3 00	..	..	..	3 00
Repairs to typewriter	2 50	..	..	..	2 50
Gold medal and engraving	16 25	..	..	..	16 25
Discount on foreign remittances	07	..	..	06	13
Expenses Newport Branch	21	..	..	..	21
Expenses Washington Branch.	..	20	14	14	48
Annual Prize	..	100 00	..	..	100 00
Expenses business trips	..	2 75	2 50	1 40	6 65
Half profits to Comdr. Glass on No. 34	..	10 51	..	..	10 51
Subscription Navy and Marine Corps Directory	..	..	5 00	..	5 00
Transfers from credits	..	..	..	2 80	2 80
Totals.	$466 37	$1131 51	$725 53	$1120 16	$3443 57

SUMMARY.

Balance of cash unexpended for the year 1891	$2050 02
Total receipts for 1892	5373 25
Total available cash, 1892	$7423 27
Total expenditures for 1892	3443 57
Cash unexpended, January 1, 1893	$3979 70
Cash held to credit of Reserve Fund	42 89
True balance on hand, January 1, 1893	$3936 81
Bills receivable for dues 1892	567 60
" " " back dues	539 50
" " " binding.	12 50
" " " subscriptions	8 00
" " " sales.	14 52
Value of back numbers (estimated)	1875 00
" " Institute property (estimated	100 00
Total assets	$7053 93

The liabilities of the Institute consisted on January 1st of the balance due on the bill for printing whole No. 64, which had not been delivered on that date, and a small bill for second class postage, neither of which bills had been rendered.

Reserve Fund.

List of bonds deposited for safe-keeping in the Farmers' National Bank of Annapolis, Md.:

United States 4 per cent consols, registered	$900 00
District of Columbia 3.65 per cent registered bonds	2000 00
" " " 3.65 per cent coupon "	450 00
	$3350 00
Cash in bank uninvested	42 89
Total Reserve Fund	$3392 89
Number of new life members, one the prize essayist for 1892	2

Of the above amount invested, there were added during the year two District of Columbia bonds, 3.65 per cent, face value $100.00, which were purchased for $114.30.

Membership.

The membership of the Institute to date, January 1, 1893, is as follows: Honorary members, 6; life members, 105; regular members, 553; associate members, 188; total number of members, 852.

During the year 1892 the Institute lost 15 members by resignation and 7 by death; 35 new members' names were added to the rolls — 10 regular, 23 associate, and 2 life members; 1 regular member became a life member.

Members Deceased since January 8, 1892.

Life Members.

Bolles, T. Dix, Lieutenant, United States Navy, August 23, 1892.

Regular Members.

Clark, A. B., Chief Engineer, United States Navy, April 19, 1892.
Dalrymple, E. W., June 21, 1892.
Roosevelt, N. L., December 14, 1892.

Associate Members.

Cowles, Eugene H., ——, 1892.
Drayton, Percival L., June 24, 1892.
Wright, Geo. F., August 20, 1892.

Publications on Hand.

The Institute had on hand at the end of the year the following copies of back numbers of its Proceedings:

	Plain copies.	Bound copies.		Plain copies.	Bound copies.
Whole No. 1	104	..	Whole No. 33	9	162
2	240	..	34	35	28
3	61	..	35	141	6
4	146	..	36	263	29
5	121	..	37	192	24
6	1	..	38	231	2
7	7	..	39	220	2
8	35	..	40	25	113
9	39	..	41	251	19
10	5	..	42	105	19
11	215	..	43	156	3
12	52	..	44	55	10
13	3	..	45	38	19
14	4	..	46	41	19
15	1	..	47	21	19
16	221	..	48	40	18
17	..	..	49	18	17
18	103	..	50	56	17
19	103	..	51	29	18
20	118	1	52	51	16
21	227	1	53	146	35
22	268	1	54	5	8
23	176	1	55	54	17
24	186	1	56	535	55
25	1139	45	57	14	22
26	204	80	58	..	22
27	300	27	59	..	13
28	2	17	60	93	2
29	211	9	61	180	20
30	245	6	62	192	20
31	37	57	63	371	6
32	3	173			

1 Vol. X., Part 1, bound in half morocco.
1 No. 34, bound in half morocco.
3 " " " " " calf.
1 " " " " full sheep.
4 " 63 " " flexible leather.
15 " " " " " cloth.

Very respectfully,
H. S. KNAPP, *Lieut., U. S. Navy,*
Secretary and Treasurer.

ANNAPOLIS, MD., January 1, 1893.

Vol. XIX., No. 2. 1893. Whole No. 66.

PROCEEDINGS

OF THE

UNITED STATES

NAVAL INSTITUTE.

VOLUME XIX.

EDITED BY H. S. KNAPP.

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BALTIMORE, MD.

The writers only are responsible for the contents of their respective articles.

CONTENTS.

of those now among my hearers may have been so fortunate as to hear, at former sessions, his admirable exposition of its principles, with particular reference to the circumstances of naval officers, and the perplexities which they may encounter. This association of the past, together with his present official position, combined to indicate him pointedly as the most proper person to deliver this opening address; for, in addition to the strong personal reasons I have mentioned, his presence would have been the manifest token of the cordial interest now extended by the Navy Department, the want of which was keenly felt in the first strong and, I may boldly say, not unsuccessful effort to develop the art of naval war. The premature blight that fell upon our early endeavors did not wholly obliterate the recognition of the decisive advance made during our brief and checkered existence. Of this I have had the assurance, both directly by word and indirectly by action, from so many that attended the former courses, that no fond self-deception can account for the conviction I now express, of the results obtained by those of whom I was for most of the time the nominal head.

To my urgent and repeated requests the Assistant Secretary gave no more than a conditional promise; and I owe only to myself that I so far depended upon it as to have deferred to the last three days such hurried preparations as I have made, personally, to meet this audience, and, so far as in me lies, replace the loss which we have to regret. To the embarrassment of scanty time, for which I have to blame my want of prevision, is added in my case the fact that I have already, on a former opening, delivered an address in which I explained at some length the objects and aims of the College from my own point of view, which I may add was that of my then immediate superior, the Chief of the Bureau of Navigation, who to-day is with us as the commander of the Squadron of Evolution. Had that address then gone no further, it might now, after the lapse of four years, have been resurrected like the sermon from the proverbial barrel and done duty again; but having incautiously been allowed to pass into print, and somewhat widely distributed within the service, this resource is not now open to me.

Like all new departures, however, the College has to encounter not merely constructional difficulties, the friction which inevitably attends every effort to do something which has not been done before, and which formed the subject of my former address. It has to

encounter the more formidable, because more discouraging, obstacles of direct objection, based often on reasonable grounds; more often, perhaps, on unconsidered prejudice. Of the former, the reasonable criticism, I shall now only say that I trust there will always be found in the College representatives an open and dispassionate mind, ready to receive, consider and profit by suggestions from whomsoever coming. I propose to-day to devote my remarks only to those objections which, while superficially plausible, are, I am convinced, due to the lack of reflection and to the tendency we all have to be influenced by words or phrases, without pausing to reflect that, in their true and commonly received meaning, they are not really applicable to the thing to which they are, for the moment, applied.

Take, for instance, the word "obsolete." I doubt if there is any one word in the language that has done so much harm to the U. S. navy as this little one in its misapplied, yet common use, during a period of years with which I and many of my hearers have been contemporary. The ship built to-day, it has been freely said, will be "obsolete" ten years hence; nay, we were fortunate if we escaped the stronger yet equally positive assertion that the ship laid down to-day will be "obsolete" by the time she can be launched. What was the result of this seemingly slight and harmless exaggeration of talk? Why, simply this: That with all the valuable services and prestige of the navy during the Civil War, with the popular favor still green, with Farragut scarcely yet in his grave, everything like naval advance was stopped because of the threat of obsolescence. "Of what use," asked the unprofessional citizen, safe in an immense professional backing in the use of this word and its ideas, "of what use to build ships which are so soon to be obsolete? Let us wait until we have reached something that will not become obsolete." So we waited, with our hands and energies ironed by the little word "obsolete" until, less than ten years ago, the material of the American navy was the derision of the world and the mortification of our officers; and even now, despite the judicious and untiring efforts of recent secretaries, we have not and, for some years to come, will not have a navy commensurate with our national importance, or fitted to fulfil the fast growing sense of our proper sphere and influence in the world outside our borders. Within two years I have seen the American navy styled a phantom fleet by an English newspaper of the first rank.

How ready, all this time, the country really was to respond to an intelligent presentation of the necessities of a navy, has been shown by the liberal appropriations, and yet more by the liberal expressions of men of all parties and shades of opinion; despite this being a time, in which, until very lately, party divisions turned more on tradition than on living issues. What stopped advance was not the unwillingness of the country, but the cry of "obsolete." Yet in what other practical walk of life is advance thus conditioned? What technical calling refuses to make a step forward, because the ground it reaches to-day will be abandoned to-morrow? Who would ever dream of saying that iron rails are obsolete, in the sense that they are of no use at all, because steel rails are found to be better? And finally, before quitting the subject, what is the last, and, in my judgment, most rational, expression of foreign professional opinion concerning these so-called "obsolete" ships? Simply, yet most significantly, this: That the nation which, in the later stages of a war, be it long or short, when the newest ships have received their wear and undergone their hammering, the nation which then can put forward the largest reserve of ships of the older types, will win the struggle.

So much for "obsolete." Before passing, however, to the word upon whose erroneous application I desire chiefly to fix your attention, I want to-day to allude to an idea closely akin to "obsolete," which, though widely spread and accepted, has not, so far as I know, been formulated into a phrase with which to pass current. I allude to the view that naval history, in which is embodied the naval experience of past ages, has no present utility to us. When I was first ordered to the College, before even I had begun to develop the subjects intrusted to me, an officer, considerably my senior in rank, asked what I was going to undertake. On my naming naval history, he rejoined, "Well, you won't have much to say about that." The words, I fear, voiced a very general feeling, an impression of that vague and untested character which is ever to be deprecated when it is allowed to become a potent factor in determining action. It struck, I am free to confess, a chord in my own breast; nay, I am glad to avow that it did so, for whatever small value my own opinion may possess can lose nothing, but rather gain, by the admission that study and reflection have resulted in displacing that most powerful of resistant forces, an unintelligent

prejudice. I am, however, happy to be able to support my own conclusions, which rest upon no proofs of personal capacity for the management of modern naval fleets, by that of one of the foremost admirals now living, belonging to the largest navy in the world. The name and repute of Admiral Phipps Hornby is known, I presume, to all naval officers; certainly in his own service, where he has commanded the most modern fleets with distinction, his opinions are quoted with respect not far removed from reverence. In a letter he was kind enough to write me on a published work of mine, which embodied the results of my lectures at this College, he said: "I am glad to see that, like the German army, you base your conclusions upon the history of the profession."

I come now to the matter upon which I wish more particularly to speak; and here again I will illustrate by one of those casual conversations, which, like straws, often show more clearly than deliberate utterances how the wind of professional prejudice is blowing. I was in Washington a few months ago and, coming out of one of the clubs, I met on the door steps a couple of naval officers. We stopped to talk, and one asked me: "Do you expect a session of the College this year?" I replied that I hoped so. "Well," he said, "are you going to do anything practical?" I recognized my enemy at once in the noble word "practical," which has been dropped like an angel of light out of its proper sphere and significance, and made to do duty against its best friends, as a man's foes are often those of his own household. I endeavored to get out of the scrape, which would involve an *extempore* discussion of the true scope and meaning of the word practical, by resorting to the Socratic method, liberally practiced by the modern Irish, which would throw the burden of explanation upon my questioner. "What do you mean by practical?" I said. The reply was a little hesitating, as is apt to be the case to a categorical question, and after a moment's pause he said: "Well, torpedo-boats and launches and that sort of thing."

Of course, I knew in a general way what was coming, when I asked my question; nor did I in the least contest the application of the word practical to torpedo-boats or launches. Concerning the latter, in fact, it was a recommendation of my first report as president of the College, that such should be provided for practicing the far more delicate and difficult management of the ram in action

—a problem with which, I am bold to say, the naval mind has not begun to deal. But, while willing to concede this positive meaning, given to the word practical, I do most decidedly object to the implied negative limitation, which confines it to the tangible utilitarian results, to that which can be touched, weighed, measured, handled, and refuses to concede the honor of "practical" to those antecedent processes of thought and reflection, upon which the results of rational human effort always depend, and without which they cannot be reached—unless, indeed, by the bungling, tedious and painful method which is called "butt end foremost." It is to this view of the matter, and to the full legitimate force of the word "practical" that I wish to-day to direct your attention; for the limitation so frequently imposed on it, and so generally accepted by thoughtless prejudice, is the great stumbling block in the way of the College, just as I have tried to show that the word "obsolete" so long held the United States navy in a state of suspended animation.

In discussing the word "practical," I do not of course propose to go into its etymology, for the sake of making a barren argument as to what it ought to mean. I intend to accept it in its common significance, as familiar to us in current speech; and I propose to maintain that, in that sense, it is just as applicable to the processes of thought which precede action as it is to the action which follows thought and reflection; the only difference being that, taking the whole process of thought and action together, the thought which dictates the action is more practical, is of a higher order of practicalness than the resultant action itself. Of this the old and common proverb "Look before you leap" is a vigorous presentment. The word "practical," however, has become so warped—not in its meaning, but in its application—that the practical man is he who disdains the theoretical process of looking—that is, who will have no study, no forethought, no reflection—but simply leaps—that is, acts.

Of course, when you reach a *reductio ad absurdum*—if you do—the victim cries out: He never meant any such thing. Neither does the man who leaps without looking mean to reach the possibly uncomfortable berth in which he lands. But let it be observed, it is not man's nature to leap without looking; the irrational brute does not do that. Men leap without looking, because they have failed

to prepare, because they have neglected the previous processes of thought and reflection, and so, when the sudden call for action comes, it is "leap at all hazards;" and so, to quote Holy Writ, while they are saying "peace and safety," "sudden destruction comes upon them like travail upon a woman with child, and they cannot escape." How often have we—I speak at least to men of my own time—been told that presence of mind consists largely—for the average man mainly—in preparation of mind. When you take the deck, think what you will do in any emergency likely to arise —a man falls overboard, a collision threatens from this or that quarter, land or reef may be unexpectedly sighted. Good. But is the thought, which is simply study without books, less practical than the resultant action? Is it less practical, even if no call for action arises?

Let us, for illustration, draw upon an art which has supplied many useful analogies to describe processes of gradual development—that of the architect. Before erecting a building, be it one of simple design and unpretentious appearance, like that in which we are now seated, or be it one of the complicated and elaborate designs which decorate the cliffs of Newport—what careful study, plotting and planning goes on in the offices of the architect! What calculations to ensure convenience, to economize space, to please the eye. It is pure student's work, beyond which lie, not merely the experience of the architect, but also years of patient study, devoted to mastering the principles of his art as embodied in the experience of his predecessors. Before a brick is laid, perhaps before the sod is turned, the complete design—the future house—exists upon paper!

Is all this prior labor of the architect in his office, and all the varied study that has enabled him to perform it not "practical," and does the "practical" work begin only when the carpenter and the bricklayer put their hands to it? If you think so, gather your mechanics and your hod carriers, provide your material of bricks and mortar, and then, setting to work without your designs and calculations, rejoice in the evidence of practical efficiency you have displayed to the world!

All the world knows, gentlemen, that we are building a new navy—the process has begun, is going on, and its long continuance is an avowed purpose. We are to have a navy adequate to the sense of our needs; and that sense is bound to expand as our people ap-

preciate more and more, and as they are beginning to realize more and more, that a country's power and influence must depend upon her hold upon regions without her own borders, and to which the sea leads. The influence of the little British islands gives a lesson our people will surely learn. Well, when we get our navy, what are we going to do with it? Shall we, like the careless officer-of-the-deck, wait for the emergency to arise? If we do, we shall pretty surely leap without much looking. Or do you think that when the time of war comes you will find a *vade mecum,* a handy pocket manual, the result of other men's labors, which will tell you just what to do; much like one of those old seamanship problems: Riding to a single anchor and ebb tide, with the wind on the starboard bow and a shoal on the port quarter, get underway and stand out to sea. A remark to that effect was made by an officer, a commander now afloat, who I think is regarded by all as one of our most intelligent, as he certainly is one of our most advanced men. "I thought," he said, in discussing some naval problems, of the kind with which the College proposes to grapple, "that, the case arising, I could turn to some work where the dispositions of a fleet, of a convoy, and other various questions connected with maritime expeditions would be treated and their solution stated; but I find there is none, and I myself do not know." At present the matter is perhaps of little consequence; but will it not be unfortunate for the responsible officers to be in like plight, when the call for action arises?

It is a singular comment upon the line in which naval thought has long been running, that the reproach to the French navy, though it was then a very accomplished service, near 100 years ago, by one of its most thoughtful members, is equally applicable, perhaps even more applicable to the naval profession of all countries in our own day. "The art of war," said the writer, "is carried to a great degree of perfection on land, but it is far from being so at sea. It is the object of all naval tactics, but it is scarcely known among us except as a tradition. Many authors have written on the subject of naval tactics, but they have confined themselves to the manner of forming orders or passing from one order to another. They have entirely neglected to establish the principles for regulating conduct in the face of an enemy, for attacking or refusing action, for pursuit or retreat, according to position or according to the relative strength of the opposing forces."

This is painfully the case now. Not only during the time I was actually resident here, but in the four years that have since then elapsed, I have made a practice of sending for the catalogues of the leading military and naval booksellers, at home and abroad, and carefully scanning their lists. Whatever could be found bearing in any way on the art of naval war I have had ordered for the College library; with the result that a single one of the short book shelves you can see downstairs, contains all that we have to show on the subject of naval tactics; and of that space nearly one-half is occupied with elaborate treatises upon the tactics of sailing ships, from Paul Hoste to Chopart. Of the remainder, none can be quoted as an authority; and it may be questioned if any rises to the dignity of a systematic, well-digested system. They are simple, short essays, more or less suggestive; but that they possess no great weight is evident from the fact that the authors' names suggest nothing to the hearer.

The significance of this fact, however, does not lie in the mere absence of treatises. Did such exist, had we the *vade mecums*, the pocket manuals, with their rules and standards, the work of some one or two masters in the art, their usefulness to the profession would be very doubtful if they did not provoke others to search for themselves—to devote time and thought to mastering the facts, and the principles upon which the supposed masters had based their own conclusions. War cannot be made a rule of thumb; and any attempt to make it so will result in disaster, grave in proportion to the gravity with which the issues of war are ever clothed.

No, the lamentable fact indicated by this meagre result is that the professional mind is not busying itself with the considerations and principles bearing upon the Conduct, or Art, of War. There is no demand, and therefore there is no supply. There is little or no interest, and consequently there are no results. In what other department of modern life is lively professional interest unaccompanied in this age by publication? In what other is there found a total neglect of the great medium of the press, by which men communicate their thoughts to others, and at the same time an active gathering and dissemination of results? Nay, in other branches of our own profession—in gun construction, in ship construction, in engine building, in navigation—there are treatises in plenty, indicating that interest is there, that there is life; but when we come

to the waging of war there is silence, because there we meet sleep, if not death. It was said to me by some one: "If you want to attract officers to the College, give them something that will help them pass their next examination." But the test of war, when it comes, will be found a more searching trial of what is in a man than the verdict of several amiable gentlemen, disposed to give the benefit of every doubt. Then you will encounter men straining every faculty and every means to injure you. Shall we then, who prepare so anxiously for an examination, view as a "practical" proceeding, worthy of "practical" men, to postpone to the very moment of imperative action the consideration of *how* to act, *how* to do our fighting, either in the broader domain of strategy, or in the more limited field of tactics, whether of the single ship or of the fleet? Navies exist for war; and if so, the question presses for an answer: "Is this neglect to master the experience of the past, to elicit, formulate and absorb its principles, is it practical?" Is it "practical" to wait till the squall strikes you before shortening sail? If the object and aim of the College is to promote such study, to facilitate such results, to foster and disseminate such ideas, can it be reproached that its purpose is not "practical," even though its methods be at first tentative and its results imperfect?

The word "practical" has suffered and been debased by a misapprehension of that other word "theoretical," to which it is accurately and logically opposed. Theory is properly defined as a scheme of things which *terminates in speculation, or contemplation*, without a view to practice. The idea was amusingly expressed in the toast, said to have been drunk at a meeting of mathematicians, "Eternal perdition to the man who would degrade pure mathematics by applying it to any useful purpose." The word "theoretical" is, therefore, rightly and legitimately applied only to mental processes that end in themselves, that have no result in action; but it has, by a natural, yet most unfortunate, confusion of thought, come to be applied to all mental processes whatsoever, whether fruitful or not, and has transferred its stigma to them, while "practical" has walked off with all the honors of a utilitarian age.

If therefore the line of thought, study and reflection, which the War College seeks to promote, is justly liable to the reproach that it leads to no useful end, can result in no effective action, it falls justly under the condemnation of not being "practical." But it

must be frankly and fearlessly said that the man who is prepared to apply this stigma to the line of the College effort must also be prepared to class as not "practical" men like Napoleon, like his distinguished opponent, the Austrian Archduke Charles, and like Jomini, the profuse writer on military art and military history, whose works, if somewhat supplanted by newer digests, have lost little or none of their prestige as a profound study and exposition of the principles of warfare.

Jomini was not merely a military theorist, who saw war from the outside; he was a distinguished and thoughtful soldier, in the prime of life during the Napoleonic wars, and of a contemporary reputation such that, when he deserted the cause of the emperor, he was taken at once into a high position as a confidential adviser of the allied sovereigns. Yet what does he say of strategy? Strategy is to him the queen of military sciences; it underlies the fortunes of every campaign. As in a building, which, however fair and beautiful the superstructure, is radically marred and imperfect if the foundation be insecure—so, if the strategy be wrong, the skill of the general on the battlefield, the valor of the soldier, the brilliancy of victory, however otherwise decisive, fail of their effect. Yet how does he define strategy, whose effects, if thus far-reaching, must surely be esteemed "practical?" "Strategy," he said, "is the art of making war upon the map. It precedes the operations of the campaign, the clash of arms on the field. It is done in the cabinet, it is the work of the student, with his dividers in his hand and his information lying beside him." It originates, in other words, in a mental process, but it does not end there, therefore it is practical.

Most of us have heard an anecdote of the great Napoleon, which is nevertheless so apt to my purpose that I must risk the repetition. Having had no time to verify my reference, I must quote from memory, but of substantial accuracy I am sure. A few weeks before one of his early and most decisive campaigns, his secretary, Bourrienne, entered the office and found the general, as he then was, stretched on the floor with a large map before him. Scattered over the map, in what to Bourrienne was confusion, were a number of red and black pins. After a short silence the secretary, who was an old friend of school days, asked him what it all meant. The general laughed goodnaturedly, called him a fool, and said: "This set of

pins represents the Austrians and this the French. On such a day I shall leave Paris. My troops will then be in such positions. On a certain day, naming it, I shall be here, pointing, and my troops will have moved there. At such a time I shall cross the mountains, a few days later my army will be here, the Austrians will have done thus and so; and at a certain date I will beat them here," placing a pin. Bourrienne said nothing, perhaps he may have thought the matter not "practical;" but a few weeks later, after the battle (Marengo, I think) had been fought, he was seated by the general's side in his military traveling carriage. The programme had been carried out, and he recalled the incident to Bonaparte's mind. The latter himself smiled at the singular accuracy of his predictions in the particular instance.

The question I would like to pose will, in the light of such an incident, receive of course but one answer. Was the work the general was engaged on in his private office, this work of a student, was it "practical?" Or can it by any reasonable method be so divorced from what followed, that the word "practical" only applies farther on. Did he only begin to be practical when he got into his carriage to drive from the Tuileries, or did the practical begin when he joined the army, or when the first gun of the campaign was fired? Or, on the other hand, if he had passed that time, given to studying the campaign, in arranging for a new development of the material of war, and so gone with his plans undeveloped, would he not have done a thing very far from "practical?"

But we must push our inquiry a little farther back to get the full significance of Bourrienne's story. Whence came the facility and precision with which Bonaparte planned the great campaign of Marengo? Partly, unquestionably, from a native genius rarely paralleled; partly, but not by any means wholly. Hear his own prescription: "If any man will be a great general, let him study." Study what? "Study history. Study the campaigns of the great generals—Alexander, Hannibal, Cæsar," (who never smelt gunpowder, nor dreamed of ironclads) "as well as those of Turenne, Frederick and myself, Napoleon." Had Bonaparte entered his cabinet to plan the campaign of Marengo, with no other preparation than his genius, without the mental equipment and the ripened experience that came from knowledge of the past, acquired by study, he would have come unprepared. Were, then, his previous study

and reflection, for which the time of action had not come, were they not "practical," because they did not result in immediate action? Would they even have been not "practical" had the time for action never come to him?

As the wise man said, "There is a time for everything under the sun," and the time for one thing cannot be used as the time for another. That there is time for action, all concede; few consider duly that there is also a time for preparation. To use the time of preparation for preparation, whatever the method, is practical; to postpone preparation to the time for action is not practical. Our new navy is preparing now; it can scarcely be said, as regards its material, to be yet ready. The day of grace is still with us—or with those who shall be the future captains and admirals. There is time yet for study; there is time to imbibe the experience of the past, to become imbued, steeped in the eternal principles of war, by the study of its history and of the maxims of its masters. But the time of preparation will pass—some day the time of action will come. Can an admiral sit down and re-enforce his intellectual grasp of the problem before him by a study of history, which is simply a study of past experience? Not so; the time of action is upon him, and he must trust to his horse sense. The mere administration and correspondence of a fleet leaves all too little time. Even with captains, the administration of a single ship of the modern type makes demands that leave little time for the preparation of study. Farragut bewailed this burden; and Napoleon himself admitted, in his later days, that he never did better work than in his first campaign, to which he brought preparation indeed, but the preparation rather of the student than that which is commonly called "practical." The explanation he gave was this: That in the first, though inexperienced, he had more time for thought, more time maturely to consider and apply the knowledge he possessed, and which he then owed, not to what is called "practical work," but to the habits of study. Ten years later he had had much more practice, but he did not excel the early work, for which his chief preparation lay in a course of action what is now commonly damned as "theoretical." At the later day the burden of administration lay too heavy, but he had so used his time of preparation that, though he did not improve, he was able to bear it.

Bonapartes, doubtless, are rare—for which very reason, perhaps, that which he found necessary cannot be inexpedient for lesser men—and even below the rank of great genius few can expect to attain the highest degree of excellence; but we all look forward to command, in one way or another, and command in our profession means liability to be called on for action, of a rare and exceptional type, for which preparation by previous action may not, probably will not, have been afforded. To each and all of us that test may come, and according to our previous preparation it may be opportunity, or it may prove to be ruin. Let us not deceive ourselves by the unquestionable excellence that our service has attained in the common and peaceful line of its daily duties. That it has so done has been due to two causes: first, the admirable preparatory study of the Naval Academy; second, the opportunity for putting in practice what is there learned. But neither in study previous, nor in practice, is any provision being made for the stern test of war; nor do the occupations of peace provide other than a part, and that the smaller part, of the equipment there needed. The College has been founded with a view to supply the preparation, by antecedent study, and by formulation of the principles and methods by which war may be carried on to the best advantage. That this purpose is "practical," seems scarcely open to question. That success may be attained only after many mistakes and long effort, is merely to say that it shares the lot of all human undertakings.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

WARSHIPS AND NAVAL WARFARE.

By Ch. Chabaud-Arnault, French Naval Commander, Retired.

Translated, by permission, from the *Revista Maritima Brazileira.*

By Professor Jules Leroux, U. S. Naval Academy.

For twenty-five or thirty years—since the War of the Rebellion in the United States and the war between Brazil and Paraguay—up to the present date, the warship and naval warfare have made vain efforts to pursue their true courses without deviation, and follow, in a rational manner, the fundamental principles that must prevail in the construction of the different types of the former and in the general direction of the operations of the latter. At the present time those principles finally appear to be emerging from the obscurity that enveloped them; and, while disclaiming the rash pretense of fixing them here upon a firm and complete basis, we may at least try to sketch their main outlines. During the last quarter of a century we have constantly seen arrayed against one another the champions of enormous armor-clads and those of diminutive torpedo-boats; the advocates of the 100-ton gun and of small ordnance; the partisans of squadron operations and of individual cruisers; each side being most conclusive in its conceits and unwilling to consider but one object, where inevitably several must always exist. Hence, those men who persisted in seeking the truth between the extreme ideas of theorists came to be looked upon with distrust and were sneered at. But the hour of triumph has come for the latter, and their wisdom is finally to be rewarded; at least we trust so.

In order to thoroughly understand the change of ideas that is taking place in regard to this matter, we must, first of all, guard

against mixing up the two intimately connected yet distinct elements composing the art of war, *viz.*, tactics and strategy.

At sea as well as on land, tactics is the art of using to the best advantage on the battle-field the forces one has under his command. There alone the direct implements of attack and defense—weapons—find their use; guns and armor, rams and double bottoms, torpedoes and protective nets are nowadays the principal weapons, offensive as well as defensive, of a man-of-war.

At sea as well as on land, strategy is the art of "determining the decisive points of the seat of war, and the lines or general routes along which armies must move in order to reach them." And strategy as well as tactics has not only its weapons, but its own appropriate means; the principal of these for warships being speed, seaworthiness, extent of radius of action, habitability (suitable living accommodations); in one word, what we shall call nautical qualities, as distinct from purely military qualities, which tactics alone can utilize.

Now, if the latter, by being transformed in sympathy with the weapons, make necessary great changes in tactics, the former, *i. e.*, nautical qualities, constitute, on the contrary, the immutable bases of naval strategy, whose fundamental principles consequently cannot vary. At all times, indeed, in the past as well as in the present, superiority of speed, the ability to keep the sea longer and under better conditions than the adversary, while giving better comforts to the crew, have been and still are the essential qualities of the large battle-ship, which qualities enable it to reach in the minimum space of time the "decisive points of the seat of war" and to sail with a minimum loss of efficiency over the "general routes along which it must move to reach them;" in other words, enable it to accomplish entirely the object of strategy.

We therefore repeat, if naval tactics must change with the armaments and composition of fleets, "naval strategy is immutable, at least in its principal lines."

It is because they forgot or neglected this great and fundamental principle, that many naval theorists strayed in the pursuit of an unrealizable object, and it is for this reason that they gave the *rôle* of the torpedo and torpedo-boat an exaggerated importance. They wanted to sacrifice to speed nearly all the other qualities of a fighting ship, assuming that on board the craft of their dream men must be

made absolutely subordinate to machines; and, on the other hand, unwilling to take into the least account the teachings of history as well as the inalienable rights of humanity, they have taken the Quixotic notion of completely upsetting the object of naval strategy, and have inaugurated a system of warfare, which, if put into practice by commanders, would revive the worst epochs of barbarity.

We shall try to prove that these are just so many errors, inconsistent with certain necessities that have always been, and always will be, imposed by a rational prosecution of naval warfare.

As soon as the first high-speed torpedo-boat was designed and built, the majority of naval officers recognized that a new and terrible weapon of war had made its appearance. Still, there were some skeptics; but their scoffings were soon met by the evidence of the very important *rôles* filled by half-a-dozen Russian torpedo-boats during the naval war carried on on the Danube in the years 1877–1878. As an offset there sprang up at that time a party of officers who rested a whole system of naval warfare upon the almost exclusive use of torpedo-boats, backed only by a few gunboats proportionately small and fast, and also by a very limited number of cruisers.

Great speed, number and invisibility (relative only, of course) were the three conditions all naval men have considered from the beginning, and, indeed, should still consider, as indispensable to the success of a torpedo-boat. Now, of the above three conditions the last two involve necessarily a reduction of size, for a fixed amount of money will only buy a large number of boats on the express condition that the cost of each one of them shall be moderate, entailing as a consequence a reduced size of hull; on the other hand, the smaller that hull be, the less visible to the R. F. cannon of the enemy. It can then be affirmed that the chances of success of such a boat will diminish in proportion as its size will increase, for it is at the expense of its purely military or tactical qualities that it is sought to increase its nautical or strategic qualities: endurance—in other words, protracted maintenance of speed—seaworthiness, habitability, extended radius of action, which are all indispensable to enable it to follow away from the coasts large warships, whether they be armored battle-ships or cruisers.

To the unrealizable desire to build a war-craft fulfilling those contradictory conditions the seagoing torpedo-boat owes its creation. At the present hour the latter consists of a light-built hull

of from 100 to 150 tons, bigger than a boat and smaller than a ship, generally provided with three or four torpedo-tubes and about the same number of R. F. cannon, capable, under favorable sea conditions, of proving a real help to an armored vessel, though rather as a torpedo-catcher than in any other capacity; but losing at the same time both fighting and nautical qualities the moment the sea becomes the least rough. Then the firing of the torpedoes becomes uncertain, when not utterly impossible, its speed falls much below the average, and the strain becomes excessive for men and machinery, and in any event its radius of action, owing to its limited supplies, is far more restricted than that of a larger craft.

As to the vessels—real ones these, owing to their dimensions—called torpedo-scouts, despatch torpedo-boats and torpedo-cruisers, we vainly ask, why is this qualifying word "torpedo" added to the names? In reality, no essential difference exists between them and those that are simply designated by the names of scouts, despatch boats, and cruisers, without adjuncts. Every one in its corresponding class is provided with very nearly the same number of torpedo-tubes and small rapid-firing batteries.

The preceding considerations clearly show that besides boats, simple fast boats of 20 to 70 tons, basing their offensive as well as their defensive power on their speed, number and invisibility, there can be no torpedo-boats properly so called. The self-sustaining torpedoer, as well as the small gunboat (bateau canonnier), fitted to fulfil all sorts of tasks, and to fight on the high seas as well as near the coasts, is nothing but a chimera born of the exaggeration of an idea, correct in itself, and fraught with good results. The moment that the "boat" becomes transformed into a vessel through the necessary increase of its dimensions, in order to extend its radius of action and sail away from the coast, it renounces two of its three essential qualities, *viz.*, number and invisibility; and it, the scorner of armor, is constrained to put on armor, in order to protect its vitals, at least, against the effects of quick-firing cannon by increasing the thickness of part of its hull. At the same time its deck is armed with a secondary battery, and its stem with a ram. Here we have no longer a torpedo-boat, but any craft whatever, be it scout, despatch boat or cruiser.

The principle of the division of labor has also been invoked, with as little success as a plea for the substitution of the torpedo-boat and

fast gunboat for the larger vessels of the actual fleets. If we were to believe in certain theories, the inevitable application of that principle would lead to the building of hulls of small dimensions, all of the same type, each provided with one single weapon—gun, automobile torpedo or spar-torpedo. Assembling then the three kinds of boats thus obtained, a fighting unit would be constituted, sufficient for every task. It would be impossible to emit a more radically absurd idea. As the Secretary of the United States Navy has expressed it, in a sentence as remarkable for its conciseness as for its clearness, if it is desired to put the principles of the division of labor into sound practice in this case, it becomes necessary, on the contrary, to "build ships of different types for different objects, each one as perfect is it is possible to make it—battle-ships, cruisers and coast defense vessels;" and, as the galley of the sixteenth and seventeenth centuries carried at the same time guns, a ram and soldiers, ready to invade the deck of the adversary, there is no plausible reason why the modern man-of-war should not, size permitting, be provided with all the weapons that may be useful to it. The consequence is that, far from the armored battleship being given its death-blow by the diminutive torpedo-boat, as boastfully predicted, that sea-monster is still relied upon as indispensable in forming the nucleus of military fleets; and we have beheld it increasing progressively in size, as well as the cruiser and, indeed, the torpedo-boat itself. It is evident that we shall have to come to a stop in this line; finally conquered, not by the torpedo-boat, but by the cannon-ball loaded with an explosive of irresistible power, the real armor is very likely to disappear in the near future. But whilst war will be waged on the high seas, the requirements of strategy will make it imperious to build ships of different types for different purposes; some having the proportions of real ships and provided with all the suitable weapons, because intended, in case of need, to sail to any part of the globe, and to operate far from the coasts; others, on the contrary, deriving their principal power, for both offense and defense at the same time, from their number and relative invisibility, because their main, in fact their only, task will be to protect those very coasts.

Some writers on naval subjects flatter themselves that they have discovered an entirely new principle by proclaiming that superiority of speed is one of the essential factors in a successful war

whether it is a question of squadron, or cruiser acting alone. Going still further, some aver that speed constitutes a new weapon, superior to all others, as well as a nautical quality, to which should be sacrificed, in great part, those others that have been, up to the present, considered as indispensable to a man-of-war. Now it can be easily demonstrated that, at all times, speed has constituted at sea the first perhaps of all strategic advantages, and on the other hand, experience has already shown that it would be ill-advised to regard as of secondary importance certain qualities of the fighting ship, some nautical, others military—less brilliant on the outside, but more solid than actual speed.

History warrants us in basing the first of these two propositions upon irrefutable arguments. Without going too far back in the past, it will suffice to study carefully the relation of the cruises of the Dorias, Draguts and Barbarossas, to become convinced that those famous captains owed their success to the fleetness of their galleys as much, at least, as to their personal skill and the valor of their companions in arms. At epochs nearer our times, during the wars of 1778–1783, and those of 1793–1805, the English held in check or beat completely the French and Spanish sailors, thanks only to the superior speed of their squadrons. These are facts set off clear as daylight by the close study of those memorable struggles. Thus, in the days of sailing ships as well as in those of galleys, speed at sea has been considered one of the prime elements of success, and it is in virtue of an imprescriptible strategic law as old as the first naval battle, that things are not different nowadays.

Unfortunately, it happened that with their minds stimulated, constrained, so to speak, by the exaggerations of a so-called new principle, ship builders only obtained the maximum of speed demanded of them at the expense of two other essential and kindred qualities, *viz.*, staunchness of hull and endurance of engine; that is, capacity of the latter of working for long periods at a rapid rate, without strain and unusual risk of accidents even in bad weather. It is not, indeed, necessary to be a sailor or an engineer to understand that a very light built hull, driven forward by a powerful motor, will bend and twist at every moment under the resistless action of the waves through which it will rush at a furious speed; and as a consequence the various organs of its engine will

become disjointed and sustain frictions and shocks that are bound to result in some serious mishap.

However, as long as the idea was only to build simple torpedo-boats of very high speed for immediate defense of roads and harbors, it was natural to consider only speed. The tasks of these crafts being intended to remain always local and performed within narrow limits and in usually calm waters, their need of the strategic qualities of large battleships was only of secondary consideration; with them superiority of speed itself is only a purely tactical quality; if indispensable to them on the battlefield, it is hardly so anywhere else, and then only for a very short while. There was, therefore, no inconvenience in sacrificing endurance to it.

But it is just the reverse, when we refer to a vessel intended to fight on the high seas, whose performances on the battlefield may be preceded by strategic manœuvres of rapid execution over a wide area. In such case, we say it over and over again, great sea-worthiness, habitability and endurance must go hand in hand with speed, the latter making a sacrifice if necessary. This fact has been abundantly demonstrated during the grand manœuvres executed within the last three or four years by the fleets of various maritime powers. In this connection experience is conclusive, and there is no need of waiting for the confirmation of new and real war operations.

After all, speed for large battleships is a quality far more strategic than tactical, for it is generally admitted that, with the exception of very short spaces of time, armored vessels in action will not move at their highest speed. In such circumstances, their quick turning power, their manœuvring qualities, will be of more importance than superior speed, a quality that is so precious, on the contrary, when associated with endurance, in all sorts of strategic operations. Hence it was wrong, in our opinion, to number speed among the properly so-called weapons of a man-of-war — gun, ram and torpedo; it was, above all, a mistake to write that among the latter, speed must always occupy the first rank.

We will sum up, then, by saying (1) it is a mistake to think that superiority of speed had less importance for sailing vessels than it has for steamships; (2) to that superiority, desirable as it may be, we must avoid sacrificing the others, whether they be of a nautical or fighting order.

Everybody is now familiar with the strange sights that meet him when he penetrates into the interior of a large man-of-war. This steel monster, so ponderous and strong and so simple in construction, looking at it from the outside, is, on the other hand, set in motion, steered and utilized in action by such a large number of complicated and delicate organs (we have reference here to a large armored battleship), that as many as 84 subsidiary engines have been counted on board. This is because not only the ship itself, but the guns, torpedoes, lighting, everything, is worked by steam or electricity. The direct hand of man that formerly worked helm, gun, oar, or sail, has been, in most cases, replaced by purely mechanical power, and for this reason many a naval writer predicts that "future battleships will be real monsters, whose brains will be their captains, and their nerves the wire connections," and the same writers boldly proclaim that henceforth a nation will rely for success in naval combats, far more on the perfection of her naval art than on the valor of the *personnel* of her fleet. This is, indeed, rating very low the moral qualities of man in order to extol his intellectual ones. We think, on the contrary, and every-day experience confirms our belief, that the more perfect the weapons of war at sea, the more intelligence, coolness, presence of mind and decision in the midst of the most terrible dangers—true valor, in a word—will be required of those that will handle them. Have we not, every one of us, heard it stated a hundred times that owing to the furious rush with which two hostile squadrons will meet, mingle in confused mass and dash against one another, the task of the captain will become more and more arduous? On the other hand, suppose that for one single instant any officer, engineer, chief gunner or torpedo artificer should neglect his duty, or be guilty of the least oversight, would not the ship or boat on which he serves be doomed on account of that single slip? In former times, when the sail or oar was the only propelling power of the warship, one had time to recover and look about on the battlefield, to repair the mischief done, to offset the effects of a false manœuvre or of a badly delivered broadside, because the motions and evolutions of ships were relatively very slow, and also because their means of destruction were not so sudden. It is quite different nowadays; the longest evolution lasts but a few minutes, the first blow of a ram, the first shock of a torpedo, the first well delivered broadside

the staunch ship receives gives it its death blow, or at any rate cripples it. We have a right, then, to affirm that not only the captain's gallantry, but that of every man acting under his command will more than ever before have an overwhelming influence upon the final results of naval contests. Nothing under such circumstances can make up for man's moral strength, based, not upon a professional knowledge more or less developed, but upon a truly patriotic education that will imbue each individual character with all the energy, perseverance and devotion of which it is capable. Even setting aside this primordial consideration, on the ocean still more than on land, knowledge is inadequate to insure success; love for the profession, and great familiarity with things pertaining to the sea are necessary. Will not every one suppose, for instance, that when the ship is tossed about by the waves the fireman, feeding his furnace away down in a hole laden with the offensive smell of burnt oil and grease, will require a far steadier stomach than the sailor aloft, who while taking in a sail at least breathes a pure vivifying air? Will not the torpedo artificer, shut up within the cramped and noisome shell of a boat, rolling fearfully in the least swell of the sea, have to be possessed of better sea-legs than the gunner, who formerly pointed his piece on the roomy deck of the big, solid line-of-battle ships?

If, therefore, thoroughly drilled officers and men, each in his own specialty, are necessary to man modern battleships, it is no less necessary that the entire *personnel* should possess undaunted valor and a true naval vocation.

All that we have said heretofore we will now try to sum up as follows: A ship's weapons—that is, its direct means of attack and defense—having completely changed, we will admit with everybody that the same is true of naval tactics, and in this respect the past cannot teach us any useful lesson. But, it being impossible to free naval warfare from the exigencies of a capricious and terrible element, or, after all, modify its principal objects, the nautical or strategic qualities indispensable to every type of ship in order that it may accomplish its task satisfactorily, must, of necessity, remain about what they were before. For the same reasons, if it has been found necessary to give the officers and men of the various specialties an education entirely different from that of their predecessors, we should prize in them as in the latter first of all moral qualities and sea experience.

We have just said that *naval warfare cannot, after all, alter its prime objects*; let us now try and prove it briefly.

The reverse theory has never been and never can be upheld, except through exaggeration of the new means that science has placed in the hands of attack, and refusal in most cases to take into account the analogous resources which the same science equally insures to the defense. Thus it has been claimed by some that hereafter the blockade of harbors and coasts, and the transportation and landing of troops, will be well-nigh impossible, owing to the high speed and little visibility of torpedo-boats and small cruisers, as well as the multiplicity and suddenness of their attacks. To be sure, if a squadron composed exclusively of armored ships attempted to blockade a flotilla of torpedo-boats they would not only fail in the attempt, but expose themselves to a terrible disaster; it would be equally powerless in protecting the safe passage, or the anchoring in full view of a hostile coast, of a fleet of transports possessing, like itself, only a moderate speed. But add to or substitute for your armored ships torpedo-catchers and small cruisers as numerous as the boats of the enemy, use them to blockade the latter or to convoy swift-sailing ocean steamers loaded with troops, and at once harbor and coast blockade, transportation and landing of troops, become very feasible operations. And as, in order either to blockade the enemy's coasts or safely transport troops on board vessels, one must be master of the sea, squadrons composed of large and powerful battleships will continue to be indispensable to all maritime nations desirous of retaining the power of performing those operations.

But it is alleged that in the presence of the millions of men composing the armies of the great powers, owing specially to the means of rapidly concentrating these formidable masses, no country would think of landing thirty, forty or sixty thousand men at any point, even the most favorable, of the enemy's territory. There is some truth in that assertion; only those who make it an insurmountable obstacle to the landing of troops forget that these landings are, in most cases, effected on the territory of an ally, or on a coast partly in the power of the party undertaking them. Such, for instance, was the case with Wellington's soldiers when they set foot upon the Iberian peninsula in order to aid its people to expel the French from its soil, and later on, when they invaded Belgium

to crush at Waterloo, in concert with the Dutch and Prussians, Napoleon's last army. It was also on a friendly coast that the French troops were landed in 1859, who were carried to Genoa and Leghorn to protect Piedmont and Tuscany against the aggression of the Austrians. Some years ago, during the war of Secession and that between Brazil and Paraguay, the troops that ascended certain rivers upon federal vessels or Brazilian transports, landed on portions of territory already, wholly or partially, conquered by the respective armies of the two nations. There is no reason why the same should not take place in the future.

In order to justify still further the idea of replacing squadrons composed of large battleships by flotillas of boats and very small craft, it has been alleged by some writers that henceforth "it will be idle and absurd for a fleet to attack coast fortifications, because the object of the naval wars of the future will be not so much the ruin of the naval power of the adversary as that of his commercial power, his wealth." Nothing can be more false than that theory, and more in contradiction with the unavoidable necessities of a great struggle, waged at the same time on both land and sea. In the war of Secession, could sea or river strongholds like Vicksburg, Mobile, or Wilmington, have been captured by the land troops attacking them, without the powerful co-operation of the federal vessels? Did not the Brazilian armorclads contribute their aid in the most efficient manner to the soldiers of that same nation in the taking of Curupaity, Humaytá and Angostura? If to-morrow war broke out (which God forbid!) between France and Italy, would not the troops of the first in order to take Genoa, or those of the second to capture Toulon, need the efficacious aid of a certain number of armored battleships?

It is not necessary to pursue further the demonstration of a truth that forces itself upon the minds most prejudiced against it, to wit: that the fundamental principles of naval strategy have remained and are bound to remain unchanged, because the prime objects of naval wars have not changed, and cannot change.

Let us now study from another point of view the question already treated in previous paragraphs. Those writers who, setting aside the teachings of common sense as well as of history, proclaim that naval warfare must henceforth be a purely "industrial" one, having, consequently, but two objects—destruction of the

enemy's merchant vessels, and ruin of its commercial emporiums—wish to establish an entirely new system of naval strategy. To be efficient, they say, war must be merciless, and torpedo-boats, which, in their opinion, are the principal weapons in privateering operations, must await the cover of night to send to the bottom the enemy's ocean steamers they will meet, with their cargoes, their crews and passengers, women and children included, without troubling themselves about ascertaining the nationality of those ships in a formal and legal manner. In the same way gunboats, the best adapted craft for coast warfare, will shell and burn unexpectedly open cities of the seaboard, without bothering about notifying, even an hour beforehand, the authorities of these populous cities or the foreign consuls residing in them, of their intentions. These theorists affirm that, conducted in that atrocious manner, an industrial naval war would soon bring to terms the nation that would happen to be the victim.

Let us first consider commerce destroying operations. In the mind of the unprejudiced reader who will carefully consult the history of the last three centuries, this truth will appear: Never has the ruin of the carrying trade of the enemy had any decisive influence upon the general results of any struggle, or upon the conditions of a subsequent peace. Every time, for instance, that the fleets of France and Spain were powerless against those of England, the first two waged a successful war of privateering against the latter. Did they succeed in conquering their rival? Not a particle! Would the case be different if to-morrow hostilities were renewed between the same countries? We will answer No! because, although the writers in the case do not mention the fact, confronting the new and powerful means of attack we find corresponding resources for defense. Thus those writers affirm that numerous French torpedo-boats scattered all over the Channel could destroy every merchant vessel that dared to venture in it. A palpable mistake, for the naval manœuvres of the last few years have demonstrated beyond a doubt that a flotilla of torpedo-catchers would promptly put a stop to the operations of the assailants. In the same way, to the French cruisers distributed over the ocean the English would oppose a greater number of cruisers that would capture them one after another. Besides, do not ocean merchant steamers possess an equal, and even a superior speed, that would

enable them to escape capture? Cannot, on the other hand, small divisions of cruisers protect, as did the frigates of old, flotillas of merchantmen? And again, do not modern merchant steamers possess more freedom than the old in changing their routes from harbor to harbor, and in selecting their ports of landing, so as to circumvent the vigilance of the cruisers and torpedo-boats of the adversary?

It has then been rightly asserted that commerce destroying operations alone will be powerless in coercing a nation struggling for its existence.

Will the second object of the exclusive partisans of "industrial warfare," that is, the ruin of the commercial marts of the adversary, lead to better results? Certainly not, in spite of the enormous range of the modern gun and the terrible effects of the new projectiles charged with powerful explosives.

In the first place, here again the defense possesses means that increase parallel with those of attack. In the daytime it can oppose guns equally powerful, and generally more numerous, and at night its dreaded flotilla of torpedo-boats; before long, no doubt, it will add the submarine torpedo-boat, which in daytime will be a tremendous auxiliary to its batteries.

But let us suppose that the defense is decidedly inferior to the attack. In case of a war between France and Italy, would the laying in ashes of Leghorn, Genoa, Palermo, or Naples put the whole of the latter country at the mercy of the first? No, a thousand times, no; no more than the ruin of Bordeaux, Havre, Cette, or Marseilles would force France to lay down her arms in the struggle for her existence. For, let it be remembered, a merciless war has this peculiarity; it inspires the weak with courage, a desperate courage, and not only courage, but a savage hatred and a thirst for revenge, from which several future generations will suffer. This is a truth that shines forth on every page of history.

Unfortunately, when the human mind swerves from the true path it will not stop, and we see writers (fortunately the exception, we must confess) proclaiming that war means the total ruin of the enemy; "neither age, sex, nor prisoners must be spared." The complete wiping out of existence of the adversary must be on either side the final object. Truly, such a theory is not worth discussing; if put into practice it would move humanity from the highest state

of civilization back to one of barbarity, it would be the negation of all progress, naval and social, and, far from having as a result the end of all wars, as perhaps imagined by some visionaries, it would establish in the world a general and perpetual state of truly atrocious hostilities by fostering bloody customs and savage hatreds.

In order to sum up our opinion in regard to this momentous question of warships and naval warfare, a complete study of which would require volumes, we will set down the following: If the warship with its various types, each essential to the purpose for which it was built, is entirely different nowadays from what it was; if, as an inevitable consequence of this fact, tactics and naval combat have had, one to reform all its rules, the other to change all its means; on the other hand, the prime objects of naval strategy necessarily remain unchanged—engagements with hostile squadrons to decide the supremacy of the sea; coast and harbor blockades; co-operation with land forces in transporting troops or in attacking sea fortifications. And if we earnestly desire that certain objects of this strategy, at all times secondary ones at most, just as they are now, should disappear with common accord from the programme forced upon past, present and future squadrons from the very nature of things, it is not hard to surmise that we have reference only to the capture of merchant vessels and bombardment of the purely commercial seaports of the enemy. Were it otherwise it would be necessary to give up in despair the progress of human reason, justice and charity.

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THE VAN DUZER-MASON ELECTRIC STEERING GEAR.

By Ensign Lewis S. Van Duzer, U. S. N.

This apparatus may be fitted either as a steering gear or as a device for controlling a steam engine or other form of motor. As a steering gear it is exceedingly simple. Two reversible motors are placed at opposite ends of a worm shaft. Traveling on the shaft is a nut, bearing a sleeve which slides on the tiller to allow of rectilinear movement of the nut. The power of the motors varies with the size of the rudder, the mamimum anticipated pressure against it, and the desired speed of operations (*i. e.*, of moving the helm). Two motors are used instead of one as a measure of precaution. In case of the break-down of one, the other would be able to move the helm at a reduced speed. If the additional expense is not objected to, the motors should each be of size sufficient to develop the full necessary power, so that only one need be connected up at a time, the other being held in reserve. The carbon brushes of the reserve motor are drawn back, the current cut off and the armature allowed to revolve freely with the shaft.

When used as a controlling device for directing the movements of a Williamson or other form of steering engine—steam, hydraulic or pneumatic—the motors, much smaller of course, are arranged on a worm shaft as before described. The worm actuates a gear-wheel on the valve, or differential, shaft. The proper speed of turning the shaft is obtained by proportioning the gear-wheel and pitch of the worm to the speed of the motor. It is further controlled by an automatic switch, actuated by the engine itself, and throwing in or cutting out resistance in the operating circuit.

The wiring and the steering box (Figs. 1 and 2) are alike for both electric steerer and electric controller, except when these engines are not fitted with a "differential." In such cases the method of wiring and the connections vary according to circumstances. Nearly all cases require slightly different leads and slightly different treatment, but the general plan is the same. The wiring in all cases consists of three circuits: the main or operating circuit; the contacting, switching or reversing circuit; and the cut-out circuit. The operating circuit alone carries a current of considerable electro-motive force. It consists of two wires only, a direct and return, extending from the dynamo directly to switches or binding posts at the motor. The operating circuit may always, therefore, be thoroughly protected. The contacting or switching circuit consists of two direct wires with a common return. By means of a pair of magnets (M^2, M^3) it operates the switch a^1, which reverses the current from port to starboard, or starboard to port, as desired. Port, or starboard, here means direction only. To put the helm from 30° starboard to 15° starboard the current would switch to *port*, the movement being toward the port side. The cut-out circuit breaks the contacting or switching circuit when the helm reaches the desired position, and the contacting circuit then switches or breaks the main or operating circuit, and so shuts down the motor. The contact plates of the contact arc at the tiller (or steering engine) are so arranged as to permit of adjustment for electric lead to allow for the time required to operate the mechanism, so that the cut-out circuit really acts a short time before the tiller reaches the desired point; but by the time the motor is shut down the tiller will have arrived at its proper place. The exact amount of lead required is determined by experiment and is adjustable. It would never exceed half a second of time, and would generally be much less.

The steering-box (Figs. 1 and 2) contains as many cut-out segments as are thought to be necessary to give perfect control of the helm, and the other cut-out arc at the tiller or steering engine is a duplicate of it as regards number of segments. One small wire is needed for each segment. The current in the contacting and cut-out circuits is very small, only sufficient to actuate the magnets operating the switches. These light currents are the only ones which need to go above the protective deck. If cut or short-

circuited no harm can result to the electric plant. Only one magnet—a weak one—on the operating lever, is located in the pilothouse, and no currents of high electro-motive force need be brought near the compasses. The magnet is only momentarily in operation and ought not to effect the compass.

Any number of steering stations may be located about the ship. All should be shut off except while in use. The accompanying drawings are those made for the Patent Office, in accordance with Patent Office practice, but do not exactly represent the apparatus as it really exists. The motors shown are not reversible, and the contacts are not exactly as used in the gears now under construction.

The advantages of electric control of the helm are numerous. With little additional weight any number of steering stations can be established, and they take up so little room that they may be placed anywhere. There is no restriction of position of the electric steering lever on account of leads for shafting or rope. The labor of steering is reduced to nothing, and in particularly difficult navigation the officer-of-the-deck may, if he chooses, steer the ship himself from any one of several steering stations, aloft if necessary, as a ship can be as readily steered, electrically, from the top or masthead as from the deck.

In the mechanism above described no parts are so delicate as to render them liable to injury by the concussion of firing or ordinary rough handling. All motions are positive, and all connections and contacts are accessible and adjustable.

The working of the apparatus is as follows: With the helm at 20° port, to put it to 30° starboard push the handle H (Fig. 1) to the right. The traveling block (Figs. 3 and 4) is held by the pressure of the springs s^6, s^{6a}, until the plate L^1 touches the spring l^1 and presses it against the head of the screw K^1. The function of the springs l^1 and l^2 is to furnish a yielding contact which will be maintained even if the lever H should spring back slightly. Through K^1 the circuit is completed and flows as follows: From the dynamo through b^2 to g, thence along top of steering lever to a, thence to L^1 to K^1 to n^1 (see Figs. 3 and 4), thence through s^{6a} to D^1, thence through w^1 to M^3 and back by w^1 (return wire) to the dynamo. Magnetizing M^3 the switch a^1 is drawn over and connects the main or operating current w with e^1. The operating

current then passes through b^1 to b^{1a} and back to the dynamo, driving the motor M^1 and drawing the nut N along the shaft. If the nut N carries the tiller-sleeve (instead of, as in the drawing, working a valve for a certain form of engine) the thread on the worm shaft S^1 would be in the other direction. Supposing the thread to be in the proper direction the tiller will then continue to move to starboard. The handle H, as stated above, is now at 30° starboard, when the tiller reaches d^3, which corresponds to 30° starboard (one edge of d^3 being at about 27° and the other at 33°, 3° representing the *lead*), the cut-out circuit is completed as lollows: From the dynamo to b^2, thence along the top of the steering lever H to M^4, thence to K, to S^5, to d^4 (Fig. 2), to d^3 (by its own individual wire in the cable C), thence by s^4 to the long arc c^4 and back to the dynamo by the single return wire w^2. When this current magnetizes the magnet M^4 on the steering lever H, it draws the lever-armature a over against the light spring shown and breaks the contacting circuit. When this circuit is broken the magnet M^3 is demagnetized, the switch a^1 is released and is thrown to middle position by the flat spring q, thus breaking the main circuit and stopping the tiller.

When the main or operating current is of considerable electromotive force (*i. e.*, when the apparatus is used as a steering gear and not as a controller) the switch a^1, instead of breaking it abruptly, shuts down the motor through graduated resistance in order to avoid sparking. The adjustable contact springs are shown in Figs. 8, 9 and 10.

The Edison General Electric Company are manufacturing the above apparatus under contract with the owners of the patents. The American patent bears the date of March 7, 1893; the British patent has been applied for, but probably will not be issued for some weeks yet.

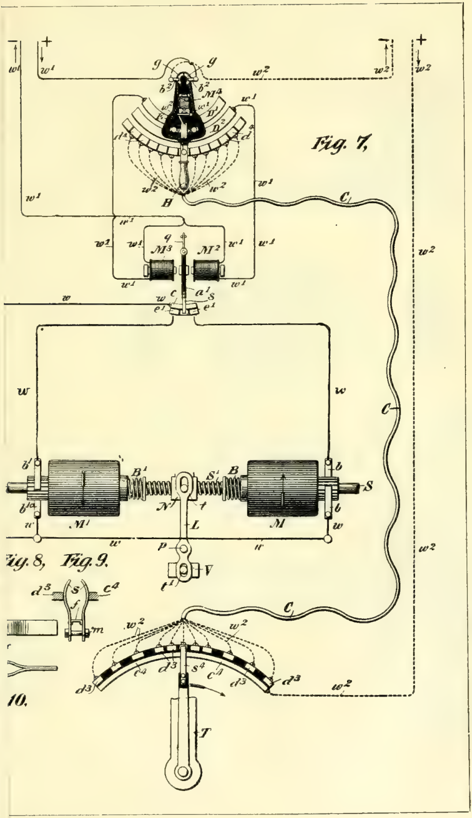


Fig. 7,

Fig. 8, Fig. 9.

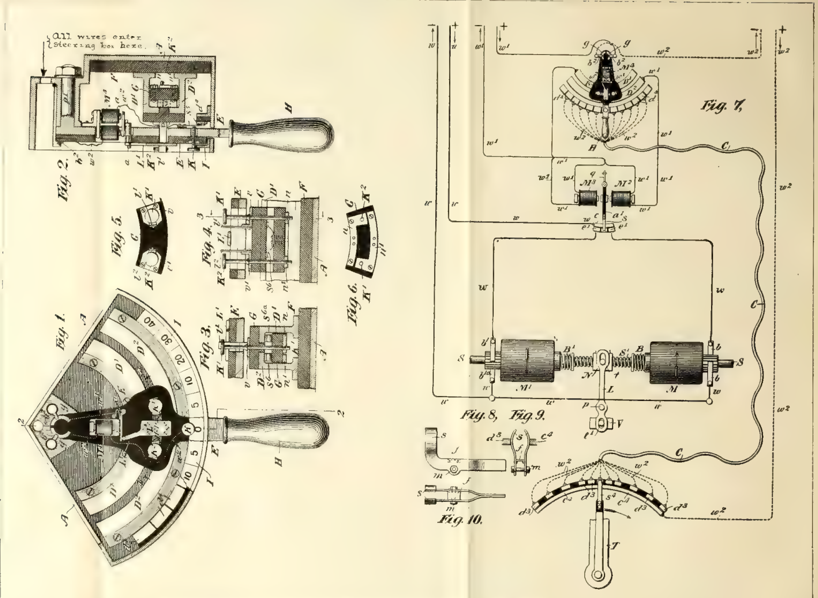
10.

current then passes through b^1 to b^{1a} and back to the dynamo, driving the motor M^1 and drawing the nut N along the shaft. If the nut N carries the tiller-sleeve (instead of, as in the drawing, working a valve for a certain form of engine) the thread on the worm shaft S^1 would be in the other direction. Supposing the thread to be in the proper direction the tiller will then continue to move to starboard. The handle H, as stated above, is now at 30° starboard, when the tiller reaches d^3, which corresponds to 30° starboard (one edge of d^3 being at about 27° and the other at 33°, 3° representing the *lead*), the cut-out circuit is completed as lollows: From the dynamo to b^2, thence along the top of the steering lever H to M^4, thence to K, to S^5, to d^4 (Fig. 2), to d^3 (by its own individual wire in the cable C), thence by s^4 to the long arc c^4 and back to the dynamo by the single return wire w^2. When this current magnetizes the magnet M^4 on the steering lever H, it draws the lever-armature a over against the light spring shown and breaks the contacting circuit. When this circuit is broken the magnet M^3 is demagnetized, the switch a^1 is released and is thrown to middle position by the flat spring q, thus breaking the main circuit and stopping the tiller.

When the main or operating current is of considerable electromotive force (*i. e.*, when the apparatus is used as a steering gear and not as a controller) the switch a^1, instead of breaking it abruptly, shuts down the motor through graduated resistance in order to avoid sparking. The adjustable contact springs are shown in Figs. 8, 9 and 10.

The Edison General Electric Company are manufacturing the above apparatus under contract with the owners of the patents. The American patent bears the date of March 7, 1893; the British patent has been applied for, but probably will not be issued for some weeks yet.

VAN DUZER-MASON ELECTRIC STEERING GEAR.



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE WHITE STRAIGHT-PULL RIFLE.

By First Lieutenant H. K. White, U. S. M. C.

The larger figure gives a general view of the breech, with details of the magazine and other parts in dotted lines. The clip is entered from above and pushed down into place by the thumb, being caught by the toe on the cut-off, as shown, this springing back to allow the projection on the back of the clip to pass below it As the clip goes down the cartridges force the follower down, compressing the feed spring. The follower has studs on each side working in circular guide grooves, so that as it moves up it is always held in position that the topmost cartridge may be in the proper position to feed into the chamber. The feed spring is of coiled wire, one end extending to the rear to bear under the follower. The other end is simply entered in its seat bored in the guard or magazine plate. When empty the clip drops out through the bottom of the magazine. Several clips are carried in the belt, charged with five cartridges each.

An improvement introduced in the clip allows it to be used with flanged cartridges and yet to be entered either side up, as the shape, combined with the new method of charging and the action of the feed in loading, causes the head of the topmost cartridge to lie forward of the one below it. Instead of entering the cartridges in the clip one at a time, the charging is accomplished in one operation from the front, the guide for the heads being formed by slitting the side plates of the clip, as shown by the dotted line, and springing in slightly the tongues thus formed. By this means the cartridge

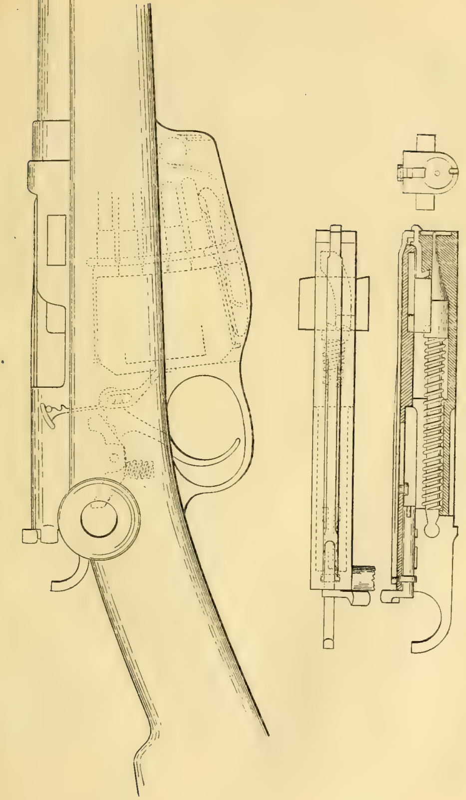
heads are allowed to pass by to the rear of the guiding edge, but are then caught and held from moving forward.

The clip detent moves up and down on the trigger pin or pivot as a guide, the upper part being provided with a head and two recesses to engage a pin on the receiver. The head is pressed down by the thumb to move the detent down to the position shown, when it is held by the pin entering one of the recesses. The clip is carried down at the same time so that the top cartridge is out of the line of movement of the bolt, and the magazine is "cut off." The piece can then be used as a single loader by dropping the cartridges into the receiver when the breech is open. The magazine can be thus "cut off" at any time, and very conveniently and quickly at the same time that the clip is inserted, by pressing down the cut-off. The magazine is put in action at any time by raising the cut-off with the first finger placed under its head; it can be plainly seen by the officer, showing whether the soldier has the magazine cut off or not. When a clip is not in, the follower forms a loading floor for use as a single loader.

The trigger has a double pull, at first easy until the sear is nearly disengaged from the firing pin; then, when the aim is exact (the fulcrum, or rather the leverage changing), a slight increase of pressure fires.

The bolt moves straight forward and back without turning. The lock is a Sharp block which moves laterally, being shown in the locked position, both ends then engaging abutments in the receiver to hold the bolt against pressure of the explosive. The block is moved to the right or left by the slide on the upper side of the bolt. A curved slot (shown in dotted lines) engages a pin on the block. When the slide is drawn to the rear by the hand on the bolt handle the block is shifted to the left or unlocked position, and when the slide is moved forward again the block is shifted to the locked position. As the block moves to the left, a projection on the firing pin, entering a recess in the block, is forced back until the block is over, when it springs forward into a smaller recess in the block to hold the latter. The firing pin is thus retracted and can never touch the cartridge except when the projection on the firing pin can enter the deep recess, *i. e.*, when the bolt is locked.

The firing pin is in two parts, united by a dovetail after the spring is put on and is inserted from above into its recess in the



bolt proper. This has its rear part cut down cylindrically to form a spindle on which the bolt slide reciprocates. The rear part of the slide is the same shape outside as the bolt and is bored out to fit the spindle. The forward part extends over the bolt as a flat plate having the curved slot above mentioned. The slide is also cut out in the rear part for the safety locking arrangement and the guide pin of the extractor locking bar. This bar is free to move with the bolt, in a slot cut in the rear part of the receiver over the bolt and its action is as follows: The bolt handle being drawn back the block is unlocked, a powerful wedge or cam action assisting the extraction, and the bolt as a whole is carried to the rear and the empty shell ejected. On moving the bolt forward, when it is nearly home, a projection on each side of the locking bar engages the receiver, and by slight spring action is held back by friction while the bolt moves forward. The extractor hook is then free to pass over the cartridge head. During the final forward motion of the slide, after the bolt proper is locked, the bar is forced forward over the extractor, entering the extractor recess under the receiver so as to be held down by the latter, thus locking the extractor positively over the cartridge head.

The safety locking mechanism is inserted in the slide from below and held from turning when in locked or unlocked position by two projections at the forward end entering slots in the slide, the end being split to allow these to spring in when turned. A collar engages slots in the firing pin to lock it either at full cock or not, and when turned over to lock the handle engages the receiver to hold the bolt fast.

All the parts interlock and no screws or screw threads are required in the breech mechanism. The locking block is first taken out in taking down the bolt. To allow the block to pass its abutment on the left side and the bolt to move back and forward, the block has a slot cut in its upper side, corresponding with the abutment when unlocked. The neck thus formed on the block moves backward and forward in a slot cut in the receiver. When the bolt is half-way back, if the firing pin is retracted to disengage its projection from the block, the latter may be taken out from the right side. The bolt can then be withdrawn from the receiver and be taken completely apart; or, by inserting the block in the bolt again, all the parts are locked together.

With the new smokeless powders the barrel becomes very hot. A part of the invention is a method of cooling it. An air space is arranged all around the barrel, a cover over it being continued as a cylinder around the muzzle. An annular space or orifice is formed around the muzzle between it and the cover. The gas, on discharge, rushing past the orifice, draws out the heated air from the space around the barrel, and fresh, cool air enters this space at the breech.

In this way is formed a complete system, the breech mechanism of but few parts, uncomplicated, and quickly taken apart and assembled. Besides the insertion of the cartridge as a single loader, or of the clip when that is used, but two motions of the hand, backward and forward, are required, making it convenient to fire rapidly without removing the piece from the shoulder.

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THE EFFECT OF ALTERATION OF PROPELLERS ON THE SPEED OF VESSELS.

By J. J. O'Neill, Member of the Society of Naval Architects and Associate Member of the Naval Institute.

The efficiency of the propeller is one of the primary and most important factors in steam propulsion, to which a great deal more attention ought to be paid. Too often a vessel goes on trial with screws totally unadapted for the speed intended; and when the same has been found wanting, other screws are substituted, whose elements are entirely different, which realize anticipation.

Whether success results from either alteration of diameter or pitch, or both, is alike a mystery.

This is an undesirable state of things, and if I am able to show the variations in speed obtained with different propellers, power being constant, on a given ship under precisely similar conditions, in which these variations can be assigned to their true cause, something will have been gained.

The importance of carefully conducted experiments must here be urged, as the value of proper, authenticated data cannot be overestimated, more especially in dealing with high-speed vessels. This can only be obtained, in so far as the propeller problem is concerned, by a systematic trial of screws, on a given ship, in which one factor alone varies. It is suggested that a propeller of a given diameter and pitch be fitted and progressive trials run, commencing with a pitch ratio of 1, and then varying the pitch by $\frac{1}{10}$ until the ratio is 1.5, the diameter remaining constant; then

reversing the process by varying the diameter, the pitch being constant. Ten progressive curves will then be obtained, showing the variations due to the alteration of each factor, which can be combined by a system of cross curves, similar to those used in stability calculations, whose value is incalculable, and which would permit of the proper propeller being chosen, at least within the limits of the experiment, for the given vessel.

It will then be found that a point exists, which it is proposed to call the *neutral point*, where any of the propellers experimented upon are of equal value for speed purposes; but that one alone is desirable when efficiency of machinery is considered, less wear and tear, and consequent prolongation of life, obtaining when the revolutions are the least possible. Further, it will appear that below the limit of the *neutral point* a relatively large propeller running comparatively slowly is the more efficient; whilst above this point, or at high speeds, a smaller propeller running quickly is more desirable for speed efficiency. The only question, then, to determine is the speed at which the conditions change.

This, of course, varies according to the type of vessels; but in ships of usual form, like war vessels, ranging from 3000 tons to 9000 tons displacement, all the data procurable seems to indicate that the point is 16½ to 18 knots, respectively. This variation is very slight when the size of vessels between these limits is considered.

It will be perfectly evident, after viewing the progressive speed curves appended, that difficulty must naturally exist in determining the necessary horse-power required to drive vessels at given speed, when the variations of speed, with similar power, due to alteration of propellers, is so marked.

No system of admiralty co-efficients of performance can obtain under these circumstances: and, in connection with these co-efficients, it may be well to state here that it will be found that one co-efficient frequently represents two distinct speeds, very wide apart, on the progressive speed curve; and further, they are absolutely of no value whatever when it may be shown that two vessels of similar type, having displacements in the ratio of 1 to 2, require the same power to obtain the same speed. In applying admirality co-efficients it is assumed, and wrongfully so, that the propulsive efficiency is constant; that is to say, that the proper propellers have

been fitted, which the curves appended clearly show may not have been the case. Again, given the progressive speed curve of a vessel, it must be clear that, in developing the ship to other dimensions, a time can never come when the same power drives both at equal rates; or two ships of equal displacements, midship areas and surfaces, having two spots on the curves, *viz.*, at 13 and 16 knots, indicating the same power, giving the same co-efficient, and yet below, between and above, having different co-efficients is inadmissable. It may further be urged that, the co-efficients being found true for two speeds on identical ships, no deviation of propellers can obtain; yet this is so, for the Scout has propellers different from those of the vessel here given, although at two distinct speeds both vessels obtain the same speed with the same power.

It is obvious, then, that any such system of computing necessary powers of varying speeds, based upon other similar vessels' performances, whose propeller elements may be entirely dissimilar, is entirely unreliable.

The method recently adopted for determining the speed from a revolution curve, after having standardized the screws, and extending the progressive speed revolution curve beyond the limits of observation, sometimes unreasonably beyond, as in the case of the Monterey, is also unsatisfactory.

Firstly, because it necessarily assumes that the propellers are the best possible for the given conditions, which, in the light of actual experiment, is exceedingly doubtful, and more especially so when we consider the case of the Philadelphia and Baltimore. These vessels are in the tabulated statement, given in the General Information Series No. XI., as identical ships of similar displacement, draft, and propellers, and yet the Baltimore develops 15 per cent. more power on three revolutions per minute less, and secures an increase of speed of four-fifths of a knot. The Terpsichore obtained 20 knots with the same power as the Philadelphia, and with the same power as the Baltimore can reach 20½ knots instead of 20 knots as given for that vessel. These results all show that the propeller problem is not yet exhausted.

Secondly, it will be found unreliable when applied to high speeds, like those obtained by torpedo-boats and vessels of small dimensions and high speed. The progressive curves of power on these vessels show decided and well marked deviations from a fair

curve at high speed, the reasons for which being now generally known—the increase of speed at the high limits being greater than that immediately below for the same increase of power; or, in other words, the same increment of power at the extreme limits of the curve giving a greater increase of speed than immediately below that limit.

This would not be apparent on the preliminary trials, where the maximum speed may not be sought for, and hence any deduction from revolutions only at the high speeds would be erroneous and misleading.

The true speed can only be deduced from any plotted curves within the limits of observation.

Everything, therefore, points to the necessity of *tank experiments*, in which not only the model of the vessel but of the screws should be put through a series of carefully conducted experiments at varying speeds, plotting results, and then finally running the actual vessel under similar conditions and comparing the theoretical with the practical curve, the difference giving the efficiency of machinery. When this has been done for varying types and the machinery efficiency determined, the prediction of results will be comparatively easy.

The method of designing vessels, and their machinery too, requires modification. The power obtained in the engine-room is no indication of the true condition of things and is relatively of no value. It is the power exerted by the propeller that determines the true value of power; and on its efficiency, as is clearly shown by the curves appended, the efficiency of the machinery.

It becomes, therefore, of primary importance that, a ship being given, the most vital basis of the design should receive the best attention. At present the only way in which some definite basis can be determined is in the manner pointed out.

It may be that the present type of ship is not the most perfect for obtaining speed, but, under the present conditions, the propeller is the *most* vital element of the design.

The behavior of the New York further exemplifies the deductions of this paper. This vessel obtained 21 knots with 136 revolutions, developing about 17,000 I. H. P.

It can safely be said that the only defense for this high rate of running machinery can be *increased efficiency of propulsion*, and the

records do not show that any such desirable result has been reached.

As far as can be judged, the machinery ran to its highest limit of speed under the conditions of trial, but for 20 knots, the *designed speed*, 90 revolutions would have been ample; with 110 revolutions 21 knots; whilst, had the propeller been otherwise, *22 knots* ought to have been reached on this power and revolutions. In other words, the New York's dimensions warrant the assertion that its *efficient speed* with the power developed is 22 knots, and the non-attainment of this should induce us to seek the cause. A reduction of diameter of propeller and increased pitch is the solution. Further, the wave formations on trial make evident to those experienced in such matters that a higher speed than that obtained is possible. These wave formations are the true indications of efficiency of the ship and machinery, and should be more carefully studied. When it is considered that $400,000 is involved in this one question, the importance of the problem can be readily appreciated.

The question of the design of the screws becomes of intense importance in the case of the Columbia, where triple screws are fitted, and their efficiency as compared with twin screws will largely depend on their dimensions.

As this vessel is essentially a high speed one, her *raison d'être* being that she be capable of outstripping, or at least overtaking, any vessel afloat, it must be urged, in the light of the advent of the Campania, that special attention be directed to this matter. Small propellers will be undoubtedly found best, and if these be fitted there can be no doubt, other things being equal, that 23 knots can be obtained, which is the true speed of this vessel.

The financial aspect of the question is worth considering even from a premium point of view. In the Columbia 21 knots is the contracted speed, and this enables a premium of $400,000 to be secured. This also applies to the New York. In the coast-line battleships of the Indiana class, whose machinery is designed to develop 9000 I. H. P., 15 knots is fixed at the speed with 128 revolutions. This great rate of running is unnecessary and injurious.

A larger propeller with 100 revolutions would be best for the machinery, giving a greater duration of life, and with this power 17 knots can be obtained, involving a premium of $200,000. The Bancroft is another case in point, where 2½ knots were obtained

over anticipation, with a premium of $500,000, due entirely to the efficiency of the propeller.

Again, the influence of the speed factor is more clearly seen in the case of the sea-going battleship Iowa, whose machinery weights permit of 15,000 I. H. P. being developed with 100 revolutions under forced conditions, whereas 16 knots is the contemplated speed with 9000 I. H. P., any increase securing premiums.

With suitable propellers 18 knots can be obtained, or 12 per cent. over anticipation, giving a premium of $200,000; under natural draft 17 knots will be reached on the specified power, which means $100,000.

This, I anticipate, will show the importance of the subject financially, and perhaps it may be well to further show what might have been done in the foregoing cases, accepting the conditions of the design as to protection, speed, armament, coal supply, etc.

Speed being the most essential factor, with that as basis, smaller ships can be built, at an enormously decreased cost, with greater manœuvring power, with all the other elements as required. Or on the same displacement, ships with from 15 to 20 per cent. greater protection and 50 per cent. greater coal supply can be produced. In the case of the Iowa the results possible are enormously in excess of the present anticipations. On same displacement, a smaller ship, having *twice* the coal supply of the Indiana, with protection greatly in excess of that vessel, can be produced, still securing a premium of $100,000. The Monterey's history is somewhat peculiar, she being designed for a speed of 15 knots, attaining only 13.6 on trial with 5244 I. H. P. and 161½ revolutions.

Yet, if speed were a primary and vital element, one can hardly realize such an unusually dimensioned vessel hoping to reach this speed. This vessel is only a *nine knot* one, that being her most efficient speed, and when a higher speed than this is sought it is at the expense of every other factor in the design; manœuvring power, steady gun platform and protection being sacrificed. When this vessel ran at speeds above 9 knots, the waves generated exposed the under surface of her armored protection for three-fourths the vessel's length, thus defeating the object for which it was placed there; in fact, it is a hindrance rather than otherwise to the vessel. This weight could have been utilized in increasing the length of the vessel and, by erecting a temporary bulwark in wake of the bow

wave, thus keeping it within the limits of the deck, the speed could have been largely augmented. Even as it is the propellers are 2'.0 too large in diameter, and if these be altered, 15 knots can be obtained on the power specified.

The subject then is of some moment; but, apart from its financial aspects, it appears to me that in designing ships the object should be to secure the *maximum effect on a minimum power and revolutions*; and this can only be secured by close attention to machinery details, as the form of high speed vessels leaves nothing to be desired; and, in short, is not of such value as is customarily supposed. The principal factor of the machinery is obviously *the propeller*; the curves appended show the marked differences due to the alteration of this element; the saving effected has likewise been shown to be enormous; and, therefore, it appears desirable to study this branch of the subject as zealously as possible.

The object in this paper has been, by giving actual results of trials, to encourage enquiry. If it should succeed in creating a desire to investigate this important question more closely, that object will have been attained.

Description of Vessel and Conditions of Trial.

	Feet.	Inches.
Length between perpendiculars	224	0
Breadth, moulded	34	0
Depth "	20	0
Draft, forward	12	6
" aft	15	6
" mean	14	0
Displacement	1600 tons.	

The trials were run with and against the tide, on a measured course of 1 mile on the north-east coast of England. Nixon's navigation coal was used on each occasion, the ship's bottom being in perfect condition. On the official trial, run in December, 1885, the mean of 6 runs with natural draft gave 17.642 knots with 119 revolutions and 4740 collective H. P. With Biles' indicator the speed was 17.66, and revolutions 120. Subsequently the forced draft trial gave a speed of 18.4 knots with 128 revolutions and a collective H. P. of 6200, 260 H. P. of which was absorbed by the auxiliary machinery.

In all cases, the vessel was trimmed to designed draft; displacement, surface, etc., all being constant, and, assuming that the conditions of trial were fairly similar, any variation obtained may be reasonably assigned to the only factor altered.

Diagram I. shows the power speed curves when the diameter was constant; the propeller efficiency curves to the left plotted to *D* and *A* bases, respectively, show the variations in speed, power being constant. The revolution curves are plotted on power basis. It will be seen that at 17 knots the propellers *A*, *B*, *C* and *D* are equal, 3650 I. H. P. being required in each case. When 6000 I. H. P. is reached, however, the variations in speed are very great, *D* obtaining three-fourths of a knot more than *B*. The dimensions of the propellers were as follows:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
A	15.9	12.6	52 sq. feet	1.26
B	16.6	12.6	47 "	1.32
C	16.9	12.6	46 "	1.34
D	18.0	12.6	46 "	1.44

Propeller *D* was finally chosen for the vessels.

Diagram II. shows the effect of variation of diameter, pitch being constant. At 16½ knots both required the same power to drive the ship, but when 6000 I. H. P. were developed *E* was found to gain three-fourths of a knot on *B*. The dimensions are as appended:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
B	16.6	12.6	47 sq. feet	1.32
E	16.6	13.0	49 "	1.27

Diagram III. shows variations due to the diameter varying, pitch constant, with screws of different dimensions from those shown in Diagram II.

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
C	16.9	12.6	46 sq. feet	1.34
F	16.9	11.9	42 "	1.43

Diagram IV. shows variations due to alteration of pitch, diameter being constant; unfortunately, only low speeds were tried, but they are here given to complete the group:

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
G	18.0	11.9	43 sq. feet	1.53
F	16.9	11.9	42 "	1.43

Diagram V. shows variations due to the variations of diameter, pitch remaining constant :

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
G	18.0	11.9	43 sq. feet	1.53
D	18.0	12.6	46 "	1.44

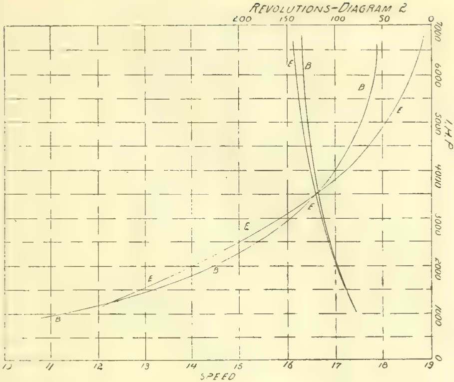
Diagrams VI., VII., VIII., group propellers of nearly equal pitch ratio together, so that the influence of alteration of both dimensions in a constant ratio can be shown.

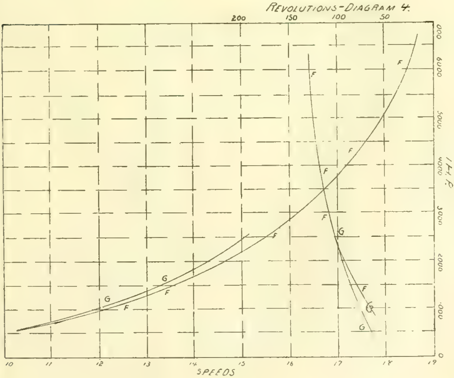
The propellers experimented upon are as follows :

	Pitch.	Diameter.	Projected surface.	Pitch ratio.
A	15.9	12.6	52 sq. feet	1.26
B	16.6	12.6	47 "	1.32
C	16.9	12.6	46 "	1.34
D	18.0	12.6	46 "	1.44
E	16.6	13.0	49 "	1.27
F	16.9	11.9	42 "	1.43

The groupings being respectively as follows:

Diagram VI., *A* and *E*, with pitch ratio..........1.26 and 1.27.
" VII., *B* and *C*, " " ....1.32 and 1.34.
" VIII., *D* and *F*, " " ....1.44 and 1.43.


REVOLUTIONS–DIAGRAM 2
200
150
100
50
0
7000
6000
5000
4000
3000
2000
1000
0
I.H.P.
E
B
E
B
E
E
E
B
B
11
12
13
14
15
16
17
18
19
SPEED


REVOLUTIONS–DIAGRAM 4.
200
150
100
50
6000
5000
4000
3000
2000
0
I.H.P.
F
F
F
F
F
G
F
G
F
G
G
F
G
10
11
12
13
14
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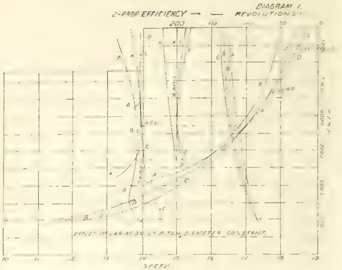
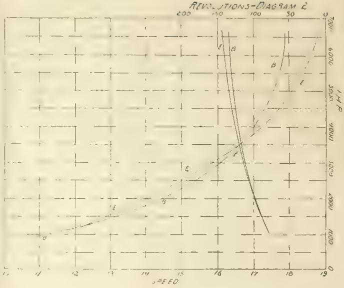
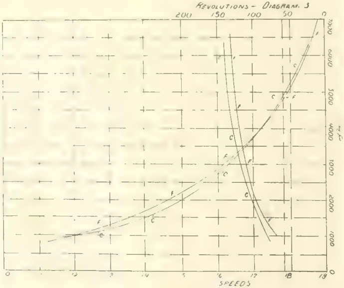
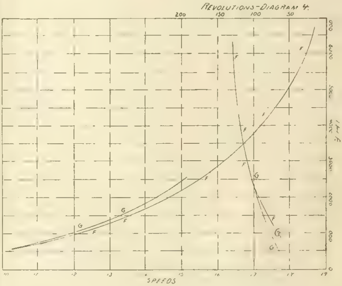
16
17
18
19
SPEEDS

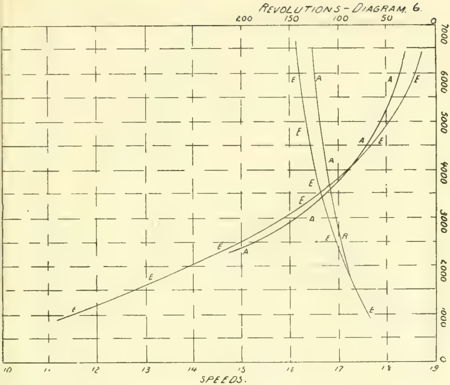
ALTERATION OF PROPELLERS.

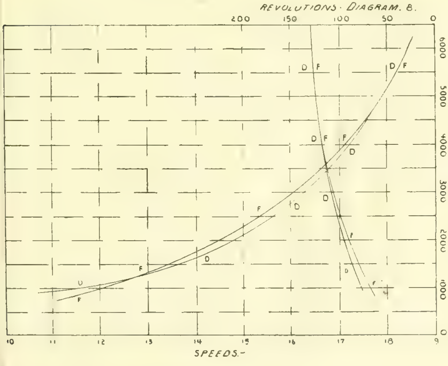


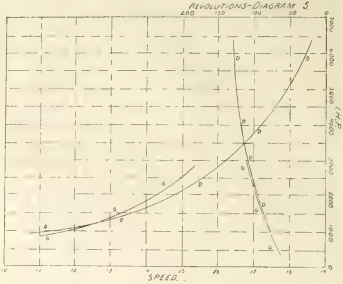







REVOLUTIONS - DIAGRAM. 6.
200
150
100
50
0
7000
6000
5000
4000
3000
2000
1000
0
I.H.P.
10
11
12
13
14
15
16
17
18
19
SPEEDS.


REVOLUTIONS · DIAGRAM. 8.
200
150
100
50
0
6000
5000
4000
3000
2000
1000
0
I.H.P.
10
11
12
13
14
15
16
17
18
9
SPEEDS.-


REVOLUTIONS-DIAGRAM 5.
200 150 100 50 0
I.H.P.
SPEED.
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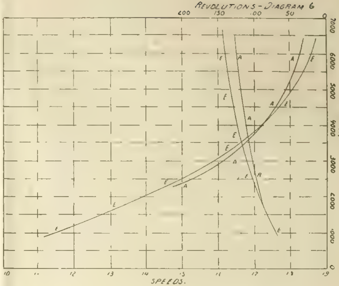
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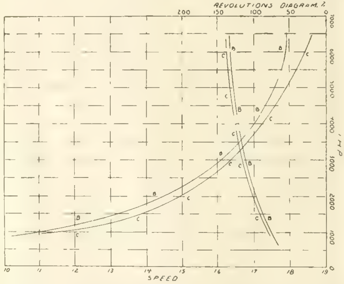
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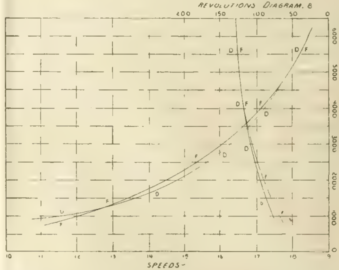
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NEGATIVE-RECIPROCAL EQUATIONS.*

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1. There is a type of equations that remain unaltered when x is changed into $-\dfrac{1}{x}$.

From the character of the roots, and from the relation that such equations bear to those named by the text-writers "reciprocal equations," the suggestive name for this type is *negative-reciprocal equations.*

In order to preserve a clear distinction, "reciprocal equations" will herein be referred to as *positive-reciprocal equations.*

To find the conditions inherent in negative-reciprocal equations.— Let the proposed equation be

$$x^n + p_1x^{n-1} + p_2x^{n-2} + p_3x^{n-} + \dots \\ + p_{n-3}x^3 + p_{n-2}x^2 + p_{n-1}x + p_n = 0 \; ; \quad . \quad . \quad . \quad (1)$$

substitute $-\dfrac{1}{x}$ for x, and divide by p_n, whence we have

$$(-x)^n + \frac{p_{n-1}}{p_n}(-x)^{n-1} + \frac{p_{n-2}}{p_n}(-x)^{n-2} + \frac{p_{n-3}}{p_n}(-x)^{n-3} + \dots \\ - \frac{p_3}{p_n}x^3 + \frac{p_2}{p_n}x^2 - \frac{p_1}{p_n}x + \frac{1}{p_n} = 0. \quad . \quad . \quad . \quad . \quad (2)$$

* This discussion results directly from investigation of a navy-professional subject that gave rise to equations of the peculiar kind. Having no clue to the simplifying of their solution, the roots were found only after much unnecessary work. The disclosing of the

2. If n be odd, the identity of equations (2) and (1) requires $p_n = -\frac{1}{p_n}$, whence $p_n = \pm\sqrt{-1}$. Therefore, negative-reciprocal equations of odd degree will be dismissed from further consideration, as involving imaginary coëfficients. This is in contrast with the case of positive-reciprocal equations, in which the coefficients are real whether n be odd or even.

If n be even and equations (1) and (2) be identical, $p_1 = \frac{-p_{n-1}}{p_n}$, $p_2 = \frac{p_{n-2}}{p_n}$, ... $p_{n-1} = \frac{-p_1}{p_n}$, and $p_n = \frac{1}{p_n}$, whence $p_n = \pm 1$. Taking, in turn, the two values of p_n, we obtain two forms of negative-reciprocal equations, thus:

Form (I.).—When $p_n = 1$, then $p_1 = -p_{n-1}$, $p_2 = p_{n-2}$, $p_3 = -p_{n-3}$, ... $p_{n-3} = -p_3$, $p_{n-2} = p_2$, $p_{n-1} = -p_1$; and we have

$$x^n + p_1x^{n-1} + p_2x^{n-2} + p_3x^{n-3} + \dots$$
$$- p_3x^3 + p_2x^2 - p_1x + 1 = 0. \quad . \quad . \quad . \quad . \quad (3)$$

Form (II.).—When $p_n = -1$, then $p_1 = p_{n-1}$, $p_2 = -p_{n-2}$, $p_3 = p_{n-3}$, ... $p_{n-3} = p_3$, $p_{n-2} = -p_2$, $p_{n-1} = p_1$; and we have

$$x^n + p_1x^{n-1} + p_2x^{n-2} + p_3x^{n-3} + \dots$$
$$+ p_3x^3 - p_2x^2 + p_1x - 1 = 0. \quad . \quad . \quad . \quad . \quad (4)$$

3. From the preceding article, we see that to have a negative-reciprocal equation, with real coëfficients, the necessary conditions are: (1st) The degree of the equation must be even; (2d) the coëfficients of the corresponding terms, counting from the beginning and end of the first member of the equation ($f(x) = 0$), must be equal numerically, and (3d) must be alternately alike and unlike in sign, giving rise to two forms of the equation, (I.) when the extreme terms have the same sign, and (II.) when they have opposite signs; (4th) the middle term $\left(p_m x^m, \text{ where } m = \frac{n}{2}\right)$ must be absent if the equation be of the first form and m be odd, or if of the

character of the roots thus obtained led to investigation for an easier solution, since the text books did not supply what was needed. The results, found useful in one direction of professional work, may prove useful to the navy officer in various directions, therefore the paper is printed here.

second form and m be even; for then the conditions giving equations (3) and (4) require $p_m = -p_m$, therefore $p_m = 0$.

4. From the identity of the proposed equation with that derived by substituting $-\frac{1}{x}$ for x, it is evident that the negative-reciprocal of any root, as a root itself, will satisfy the equation. This would indicate that the roots occur in pairs, of the form $a, -\frac{1}{a}$; $b, -\frac{1}{b}$; . . . and this condition must obtain except in the case of a root that is its own negative-reciprocal.

5. For conveniencc of treatment, negative-reciprocal equations of the dimensions $2m$ will be divided into two classes, as follows:

I. The equation will be of the first class, (a_1) if m be even and the first and last terms have the same sign, or (a_2) if m be odd and the extreme terms have different signs.

II. The equation will be of the second class, (b_1) if m be odd and the extreme terms have the same sign, or (b_2) if m be even and the extreme terms have different signs; and in this class the middle term must be absent.

From equation (3), substituting $2m$ for n, the equation of the second class (b_1), when m is odd, may be written in the form

$$x^{2m} + 1 + p_1 x(x^{2(m-1)} - 1) + p_2 x^2(x^{2(m-2)} + 1) \\ + p_3 x^3(x^{2(m-3)} - 1) + \ldots = 0. \quad . \quad . \quad . \quad (5)$$

In equation (5) the sums of the odd powers of x^2 and 1, and the differences of the even powers, occur as factors so as to render the equation divisible by $x^2 + 1$.

Similarly, from equation (4), for (b_2) when m is even,

$$x^{2m} - 1 + p_1 x(x^{2(m-1)} + 1) + p_2 x^2(x^{2(m-2)} - 1) \\ + p_3 x^3(x^{2(m-3)} + 1) + \ldots = 0; \quad . \quad . \quad . \quad (6)$$

and, as before, we have the sums of the odd powers, and the differences of the even powers of x^2 and 1.

Therefore, every negative-reciprocal equation of the second class contains the factor $x^2 + 1 = 0$, from which we derive the two isolated roots, $\sqrt{-1}$ and $-\sqrt{-1}$, each being the negative-reciprocal of itself. Since these roots are imaginary, they occur only together, and as single roots in the equation of the second class; unlike the case of isolated roots in positive-reciprocal equations, in which

1 or -1 may be a root, thus giving an odd-degree reciprocal equation; or they may occur together, giving an even-degree positive-reciprocal equation, of the second class as commonly distinguished.

Dividing a negative-reciprocal equation of the second class by x^2+1, to remove the isolated roots, the character of the roots makes the quotient a negative-reciprocal equation. Moreover, the reduced equation will be of the first class, since the signs of the extreme terms of the quotient remain the same as in the given equation of the second class, while m changes from odd to even, or *vice versa;* the condition (b_1) becoming (a_1), or (b_2) becoming (a_2).

6. The divisor x^2+1 put equal to zero gives the simplest form of negative-reciprocal equations of the second class, corresponding to $m=1$.

The simplest form of negative-reciprocal equations of the first class is the quadratic $x^2-1=0$; in which the middle term has zero for its coëfficient, though such condition is not required, the next simplest equation of this class taking the form $x^2-Ax-1=0$, in which $A=a-\frac{1}{a}$, where a is a root.

It may be of interest to note that while $x^2+1=0$ and $x^2-1=0$ are both negative-reciprocal equations, they are, at the same time, positive-reciprocal equations: that though $x^2+1=0$, as a factor, enters every negative-reciprocal equation of the second class, yet its roots are positively reciprocal: that though $x^2-1=0$, as a factor, enters every positive-reciprocal equation of the second class of an even degree, yet its roots are negatively reciprocal: that $x^2-1=0$ as a negative-reciprocal equation is of the first class, giving a pair of negatively reciprocal roots, 1 and -1; but as a positive-reciprocal equation it is of the second class, giving the two roots as isolated: that $x^2+1=0$ as a positive-reciprocal equation is of the first class, giving a pair of positively reciprocal roots, $\sqrt{-1}$ and $-\sqrt{-1}$; but as a negative-reciprocal equation it is of the second class, giving the two roots as isolated.

7. *A negative-reciprocal equation of the first class can be depressed to an equation of half its dimensions.*

With unity for the coëfficient of the first term, the given equation will be in one of two forms (Article 5, I.); thus—

(a_1) when m is even,

$$x^{2m}+p_1x^{2m-1}+p_2x^{2m-2}+p_3x^{2m-3}+\ldots+p_mx^m\ldots$$
$$-p_3x^3+p_2x^2-p_1x+1=0; \quad \ldots \quad (7)$$

(a_2) when m is odd,

$$x^{2m}+p_1x^{2m-1}+p_2x^{2m-2}+p_3x^{2m-3}+\ldots+p_mx^m\ldots$$
$$+p_3x^3-p_2x^2+p_1x-1=0. \quad . \quad . \quad . \quad (8)$$

Dividing equations (7) and (8) by x^m, and collecting in pairs the terms that are equidistant from the beginning and end, we have—when m is even,

$$x^m+\frac{1}{x^m}+p_1\left(x^{m-1}-\frac{1}{x^{m-1}}\right)+p_2\left(x^{m-2}+\frac{1}{x^{m-2}}\right)$$
$$+p_3\left(x^{m-3}-\frac{1}{x^{m-3}}\right)+\ldots+p_m=0; \quad . \quad . \quad . \quad (9)$$

when m is odd,

$$x^m-\frac{1}{x^m}+p_1\left(x^{m-1}+\frac{1}{x^{m-1}}\right)+p_2\left(x^{m-2}-\frac{1}{x^{m-2}}\right)$$
$$+p_3\left(x^{m-3}+\frac{1}{x^{m-3}}\right)+\ldots+p_m=0. \quad . \quad . \quad . \quad (10)$$

From the last two equations, we see that every term containing x to an even power is connected with the reciprocal of the same power by the positive sign, and that every odd power of x is connected with its reciprocal by the negative sign; and we may make use of two general relations, A and B, for deducing the depressed equation in terms of powers of

$$x-\frac{1}{x}=z. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

$$A\begin{cases}\left(x^{n-1}-\dfrac{1}{x^{n-1}}\right)\left(x-\dfrac{1}{x}\right)=\left(x^n+\dfrac{1}{x^n}\right)-\left(x^{n-2}+\dfrac{1}{x^{n-2}}\right); \therefore \\ x^n+\dfrac{1}{x^n}=\left(x^{n-1}-\dfrac{1}{x^{n-1}}\right)z+\left(x^{n-2}+\dfrac{1}{x^{n-2}}\right). \quad . \quad . \quad . \quad (12)\end{cases}$$

$$B\begin{cases}\left(x^{n-1}+\dfrac{1}{x^{n-1}}\right)\left(x-\dfrac{1}{x}\right)=\left(x^n-\dfrac{1}{x^n}\right)-\left(x^{n-2}-\dfrac{1}{x^{n-2}}\right); \therefore \\ x^n-\dfrac{1}{x^n}=\left(x^{n-1}+\dfrac{1}{x^{n-1}}\right)z+\left(x^{n-2}-\dfrac{1}{x^{n-2}}\right). \quad . \quad . \quad . \quad (13)\end{cases}$$

By A we have from (12), and then from (11),

$$x^2+\frac{1}{x^2}=\left(x-\frac{1}{x}\right)z+\left(x^0+\frac{1}{x^0}\right)=z^2+2; \quad . \quad . \quad (14)$$

By B from (13), $x^3 - \frac{1}{x^3} = \left(x^2 + \frac{1}{x^2}\right)z + \left(x - \frac{1}{x}\right)$, and from (11) and (14), $x^3 - \frac{1}{x^3} = z^3 + 3z$. . . . . (15)

Similarly, $x^4 + \frac{1}{x^4} = z^4 + 4z^2 + 2$; . . . . (16)

$x^5 - \frac{1}{x^5} = z^5 + 5z^3 + 5z$; . . . . (17)

$x^6 + \frac{1}{x^6} = z^6 + 6z^4 + 9z^2 + 2$; . . . . (18)

. . . . . .

It is seen that each of the expressions for $x^n + \frac{1}{(-x)^n}$ may be derived directly from the two immediately preceding, by multiplying the nearest expression by z and to the product adding the next preceding. These expressions differ from the corresponding ones $\left(\text{for } x^n + \frac{1}{x^n}, \text{ when } z = x + \frac{1}{x}\right)$ in positive-reciprocal equations, only in having the signs of all the terms positive.

8. *The forms assumed by the depressed equations.*—Taking $2m$ successively as 2, 4, 6, . . . in equations (8) and (7) in turn, m alternately odd and even, retaining, of course, only the proper number of terms, equations (10) and (9) give the following:

When $m = 1$, from (10), $z + p_m = 0$; whence $x^2 + p_m x - 1 = 0$, as given directly by (8).

When $m = 2$, from (9), $x^2 + \frac{1}{x^2} + p_1\left(x - \frac{1}{x}\right) + p_m = 0$; whence, by (11) and (14), $z^2 + p_1 z + p_m + 2 = 0$.

Similarly, $z^3 + p_1 z^2 + (p_2 + 3)z + 2p_1 + p_m = 0$;

$z^4 + p_1 z^3 + (p_2 + 4)z + (3p_1 + p_3)z + 2p_2 + p_m + 2 = 0$;

. . . .

In equations (9) and (10), then, each binomial may be expressed in terms of z $\left(\text{when } z = x - \frac{1}{x}\right)$, and the resulting equations will be of the mth degree.

9. *To obtain a general expression for* $Z_n = x^n + \frac{1}{(-x)^n}$, *in terms of powers of* $x - \frac{1}{x} = z$ (*equations* (14) . . . (18) . . .).

The sum of the nth powers of the roots of the equation

$$x^2 - px + q = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

has been shown (Todhunter's *Theory of Equations*, Arts. 260, 261) to be

$$S_n = p^n - np^{n-2}q + \frac{n(n-3)}{1 \cdot 2}p^{n-4}q^2 - \ . \ . \ .$$
$$+ (-1)^r \frac{n(n-r-1) \ . \ . \ . \ (n-2r+1)}{\underline{|r}} p^{n-2r}q^r + \ . \ . \quad (20)$$

Suppose $q = -1$, then the quadratic equation (19) is a negative-reciprocal equation, and its roots are of the form a and $\frac{1}{-a}$. Therefore $p = a - \frac{1}{a}$, in this case, and from equation (20), changing the notation, for our purpose, by putting x for a, and z for p, we have

$$Z_n = x^n + \frac{1}{(-x)^n} = z^n + nz^{n-2} + \frac{n(n-3)}{1 \cdot 2} z^{n-4} +$$
$$\frac{n(n-4)(n-5)}{1 \cdot 2 \cdot 3} z^{n-6} + ; \ . \ . \ . \quad . \quad . \quad (21)$$

it being understood that no powers with negative exponents are included, and the general term being

$$\frac{n(n-r-1)(n-r-2) \ . \ . \ . \ (n-2r+1)}{\underline{|r}} z^{n-2r}.$$

10.—RECAPITULATION.

The character of the roots in the two classes of negative-reciprocal equations may be stated as follows :

I. In equations of the first class, if a be a root then $-\frac{1}{a}$ must be another root, and there exists no root that does not observe this law. Therefore the roots all occur in pairs of negative reciprocals ; as, $a, -\frac{1}{a}$; $b, -\frac{1}{b}$; . . .

II. In the second class of these equations, $\sqrt{-1}$ and $-\sqrt{-1}$ must be two imaginary, isolated roots, while all the remaining roots occur in pairs of negative-reciprocals; as, $a, -\frac{1}{a}$; $b, -\frac{1}{b}$; . . . and in this class the middle term of the equation must be wanting.

Any negative-reciprocal equation of the second class can be reduced to one of the first class, by dividing by x^2+1; *and any negative-reciprocal equation of the first class can be depressed to an equation of half the dimensions.*

For recognition of the class of a given negative-reciprocal equation.—I. It will be of the first class if the extreme terms have like signs and the exponent of the highest power of x be of the form $4n$; or, if the extreme terms have unlike signs and the greatest exponent be of the form $4n+2$. II. The equation will be of the second class if the extreme terms have unlike signs, the greatest exponent being of the form $4n$; or, have like signs, the form of the greatest exponent being $4n+2$.

11. If the term "recurring equations" had not been given—as another name—to positive-reciprocal equations, it would seem appropriate to make that the inclusive term for the two types of reciprocal equations without discrimination—the "reciprocal equations" of the text-books, and those discussed in this paper.

The statement is hazarded here that positive-reciprocal equations will be met with no oftener than will negative-reciprocal equations—if so often. Yet the latter, so far as known to the writer, have not been noticed as a class.

In a particular direction of investigation of loci, various equations of this type have occurred, requiring solution by the writer. They have been, for the most part, of the fourth or the sixth degree, but also of higher degrees. Immediate recognition of the character of the equation would have been the means of saving much time in finding the roots.

Examples.

I. $y^4+Ay^3-Ay+1=0$; the expression of a law giving a problem met with. Dividing by y^2,

$$y^2+\frac{1}{y^2}+A\left(y-\frac{1}{y}\right)=0. \quad \text{Let } z=y-\frac{1}{y}, \text{ then}$$

$$z^2+2+Az=0;\ z=\tfrac{1}{2}(-A\pm\sqrt{A^2-8}).$$

$$y^2+\tfrac{1}{2}(A\mp\sqrt{A^2-8})y=1,$$

$$y=\frac{1}{4}\left[-(A-\sqrt{A^2-8})\pm\sqrt{2A(A-\sqrt{A^2-8})+8}\right], \text{ and}$$

$$\frac{1}{4}\left[-(A+\sqrt{A^2-8})\pm\sqrt{2A(A+\sqrt{A^2-8})+8}\right].$$

It is seen that if $A<2\sqrt{2}$ the roots are all imaginary; if $A=2\sqrt{2}$ there are two pairs of equal roots, real; if $A>2\sqrt{2}$ the four roots are all real and different.

II. $$Ay^{10}+2(A^2+1)y^9+7Ay^8-8(A^2-1)y^7-26Ay^6+(12A^2-20)y^5+26Ay^4-8(A^2-1)y^3-7Ay^2+2(A^2+1)y-A=0. \quad (1)$$

Divide by y^5 and rearrange,

$$A\left(y^5-\frac{1}{y^5}\right)+2(A^2+1)\left(y^4+\frac{1}{y^4}\right)+7A\left(y^3-\frac{1}{y^3}\right)-8(A^2-1)\left(y^2+\frac{1}{y^2}\right)-26A\left(y-\frac{1}{y}\right)+12A^2-20=0;$$

assume $z=y-\dfrac{1}{y}$, and find each binomial in terms of z, from equations (14) to (17), or from (21); then

$A(z^5+5z^3+5z)+2(A^2+1)(z^4+4z^2+2)+7A(z^3+3z)-8(A^2-1)(z^2+2)-26Az+12A^2-20=0$; therefore,
$Az^5+2(A^2+1)z^4+12Az^3+16z^2=0$; factoring,
$$z^2(Az+2)(z^2+2Az+8)=0. \quad (2)$$

From the first factor, $(y^2-1)^2=0$, whence the four roots 1, -1, 1, and -1.

From the second factor, $Az+2=0$, $y^2+\dfrac{2}{A}y=1$, whence the roots $\dfrac{-1\pm\sqrt{A^2+1}}{A}$.

From the third factor, $z=-A\pm\sqrt{A^2-8}$, whence

$$y=\frac{1}{2}\left[-(A-\sqrt{A^2-8})\pm\sqrt{2A(A-\sqrt{A^2-8})-4}\right], \quad (3)$$

$$\text{and } \frac{1}{2}\left[-(A+\sqrt{A^2-8})\pm\sqrt{2A(A+\sqrt{A^2-8})-4}\right]. \quad (4)$$

It is seen that the roots by (3) and (4) will be real or imaginary under the same conditions as in Example I., the six other roots of equation (1) being real.

III. $y^8+2y^7-3y^6-4y^5+5y^4+4y^3-3y^2-2y+1=0.$

$$\left(y^4+\frac{1}{y^4}\right)+2\left(y^3-\frac{1}{y^3}\right)-3\left(y^2+\frac{1}{y^2}\right)-4\left(y-\frac{1}{y}\right)+5=0;$$

$$z^4+4z^2+2+2(z^3+3z)-3(z^2+2)-4z+5=0;$$

$$z^4+2z^3+z^2+2z+1=0. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Equation (1) presents the singular case of the depressed equation being a reciprocal equation. It is of the first class of the positive type, therefore may be solved by depressing, thus:

$$z^2+\frac{1}{z^2}+2\left(z+\frac{1}{z}\right)+1=0; \text{ assume } w=z+\frac{1}{z},$$

$$\text{then } w^2+2w-1=0; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and, again, we have the singular case of the *second* depressed equation being a reciprocal equation—of the first class of the negative type.

From (2), $w=-1\pm\sqrt{2}$. . . . . (3)

Taking the positive sign of the radical, two values of z are imaginary, $\frac{1}{2}\left[-(1-\sqrt{2})\pm\sqrt{-(1+2\sqrt{2})}\right]$, whence four values of y are imaginary.

Taking the negative sign of the radical in (3),

$$z+\frac{1}{z}=-(1+\sqrt{2}), \text{ whence}$$

$$z=\frac{1}{2}\left[-(1+\sqrt{2})\pm\sqrt{-1+2\sqrt{2}}\right]=y-\frac{1}{y};$$

from which we obtain for the values of y,

$$\frac{-1-\sqrt{2}+\sqrt{-1+2\sqrt{2}}\pm\sqrt{18+4\sqrt{2}-2\sqrt{5+4\sqrt{2}}}}{4},$$

and $$\frac{-1-\sqrt{2}-\sqrt{-1+2\sqrt{2}}\pm\sqrt{18+4\sqrt{2}+2\sqrt{5+4\sqrt{2}}}}{4};$$

giving four real roots.

IV. $x^8-3x^6+3x^2-1=0,$ . . . . (1)

a negative-reciprocal, and a positive-reciprocal equation of the second class; therefore x^2+1 and x^2-1 are divisors, giving the

four roots $\sqrt{-1}$, $-\sqrt{-1}$, 1, and -1. Dividing equation (1) by x^4-1, we have

$$x^4-3x^2+1=0; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which, as a negative-reciprocal, and a positive-reciprocal equation of the first class, may be solved by assuming $z=x-\frac{1}{x}$ or $w=x+\frac{1}{x}$, as well as by treating it as a quadratic in x^2.

Using $z=\pm 1$, $x=\frac{1}{2}(1\pm\sqrt{5})$ and $\frac{1}{2}(-1\pm\sqrt{5})$. . . . (3)

Using $w=\pm\sqrt{5}$, $x=\frac{1}{2}(\sqrt{5}\pm 1)$ and $\frac{1}{2}(-\sqrt{5}\pm 1)$. . . (4)

Solving (2) as a quadratic in x^2, $x=\pm\sqrt{\frac{1}{2}(3\pm\sqrt{5})}$. . . (5)

It is seen that by (5) the roots do not immediately show the simplest forms, as by (3) or (4) when treated as those of either type of reciprocal equations, and grouped as of the form a, $-\frac{1}{a}$; b, $-\frac{1}{b}$, where $b=\frac{1}{a}$; or of the form a, $\frac{1}{a}$; b, $\frac{1}{b}$, where $b=-a$. By (5) the roots directly take the form $\pm a$ and $\pm b$, where $b=\frac{1}{a}$.

V. $y^8-A^2y^6+2(A^2+1)y^4-A^2y^2+1=0$.

A combined positive-reciprocal and negative-reciprocal equation, met with in the solution of a real case of roots required.

Divide by y^4, and rearrange,

$$y^4+\frac{1}{y^4}-A^2\left(y^2+\frac{1}{y^2}\right)+2(A^2+1)=0; \text{ assume } z=y-\frac{1}{y},$$

$$z^4+4z^2+2-A^2(z^2+2)+2(A^2+1)=0;$$

$$z^4-(A^2-4)z^2=-4; \text{ solving as a quadratic in } z^2,$$

$$z^2=\frac{A^2-4\pm A\sqrt{A^2-8}}{2};$$

$$z=\pm\tfrac{1}{2}\sqrt{2A^2-8\pm 2A\sqrt{A^2-8}}=y-\frac{1}{y};$$

whence we find four y's of the same values as those in Example I., and four other values equal numerically to the first four, respectively, but with opposite signs.

To have a recurring equation that combines in one the two types of reciprocal equations, it is obvious that the terms containing odd

powers of the unknown quantity must have the coëfficient zero; that if a be a root, then $-a$ must be another root; that though $\frac{1}{a}$ and $-\frac{1}{a}$, as roots, must satisfy the equation, they may not be additional roots when $a=1$ or $\sqrt{-1}$, though otherwise they will be roots necessary to the forming of the equation.

VI. For comparison, two solutions of a given equation are as follows:

1st solution, cited from *Todhunter's Algebra*, Article 333, (3).—

"Suppose $x^4+3x+1=3x^3+\frac{4}{9}x^2$. . . . . (1)

Transpose $x^4-3x^3+3x+1=\frac{4x^2}{9}$.

Therefore $\left(x^2-\frac{3x}{2}\right)^2-\frac{9x^2}{4}+3x+1=\frac{4x^2}{9}$;

therefore $\left(x^2-\frac{3x}{2}\right)^2-2\left(x^2-\frac{3x}{2}\right)-\frac{x^2}{4}+1=\frac{4x^2}{9}$;

therefore $\left(x^2-\frac{3x}{2}\right)^2-2\left(x^2-\frac{3x}{2}\right)+1=\frac{x^2}{4}+\frac{4x^2}{9}=\frac{25x^2}{36}$.

Extract the square root, then $x^2-\frac{3x}{2}-1=\pm\frac{5x}{6}$.

We have now ordinary quadratics, namely,

$$x^2-\frac{3x}{2}-1=\frac{5x}{6}, \text{ and } x^2-\frac{3x}{2}-1=-\frac{5x}{6}.$$

From the former we shall obtain

$$x=\frac{1}{6}(7\pm\sqrt{85}), \text{ and from the latter } x=\frac{1}{3}(1\pm\sqrt{10})."$$

2d solution (as a negative reciprocal equation).—Divide the given equation (1) by x^2 and rearrange,

$$x^2+\frac{1}{x^2}-3\left(x-\frac{1}{x}\right)-\frac{4}{9}=0. \quad \text{Let } z=x-\frac{1}{x}, \text{ then}$$

$$z^2-3z+\frac{14}{9}=0;\ z=\frac{1}{2}\left(3\pm\sqrt{9-\frac{56}{9}=\frac{25}{9}}\right)=\frac{7}{3} \text{ and } \frac{2}{3}.$$

Therefore, $x^2-\frac{7}{3}x=1$, and $x^2-\frac{2}{3}x=1$; from which we obtain $x=\frac{1}{6}(7\pm\sqrt{85})$ and $x=\frac{1}{3}(1\pm\sqrt{10})$.

PROFESSIONAL NOTES.

FRENCH SMALL-ARM SMOKELESS POWDER.

[*Journal of the Royal United Service Institution*, April, 1893.]

According to M. Pouteaux, in his work "La Poudre sans Fumée et les Poudres Anciennes," Dijon, 1892, the smokeless powder used in the ammunition for the French Lebel rifle, Pattern 1886, consists of a mixture of two parts of insoluble to one part of soluble nitro-cotton. He gives the following description of the manufacture: "The above mixture is worked under light runners with 2 per cent. of paraffin and 20 per cent. of water until it becomes thoroughly homogeneous. The very fine pulp thus obtained is pressed between some absorbent material to reduce the amount of moisture to about 5 per cent. The cakes from the press are broken up, and sifted on sieves of 0.6 mm. mesh, to thoroughly divide the material. The powder is dried and then submitted to the action of ether alcohol. The compressed paste is next rolled into sheets 0.5 mm. thick, and afterwards cut into squares the sides of which are 1.5 mm. long." As regards the properties of this powder, M. Pouteaux says that "it gives no smoke on firing and leaves no residue in the barrel, except a few unconsumed grains. If well made, a charge of 2.8 gm. (43.21 gr.) will give a velocity of 625 m. (2050.5 ft.-secs.) with an average pressure of 2400 kilos. on the square centimetre (15¼ tons per square inch) in the French rifle, Pattern 1886. It slows down slightly for the first two months after manufacture, the charge being increased to 2.95 gm. (52.47 gr.), after which it becomes very stable, and it keeps well if the nitro-cottons are pure. The paraffin is added to diminish its sensibility to shock, and to slightly retard the rate of combustion."

EUROPEAN SMALL-BORE RIFLES—THEIR RELATIVE VALUE.

[*United Service Gazette.*]

Professor Hebler, whose exhaustive studies on small-bore rifles well qualify him to impartially assess the value of the weapons now in use, contributes a small article to the *Allgemeine Schweizerische Militär-Zeitung* on the relative value of the various rifles used by the armies of Europe. Since the appearance of his *brochure*, "Das kleinste Kaliber, oder das zukünftige Infanteriegewehr," slight modifications in the rifle itself or in its amunition have, in some instances, altered the efficiency of the weapons; mostly, however, as in the case of the Swiss, Austrian and Bulgarian rifles, to their detriment. Taking the total ballistic perform-

ances, or "goodness," solely into account, the Professor ranges the relative value of military rifles as follows:

Spanish	7.2 mm. (.283 inch)—580
Russian	7.6 mm. (.299 inch)—540
English	7.7 mm. (.303 inch)—521
Swiss	7.5 mm. (.295 inch)—596
Belgian	7.6 mm. (.299 inch)—516
Turkish	7.6 mm. (.299 inch)—516
German	7.9 mm. (.311 inch)—474
Austrian	8.0 mm. (.315 inch)—440
Bulgarian	8.0 mm. (.315 inch)—440
French	8.0 mm. (.315 inch)—433
Danish	8.0 mm. (.315 inch)—411
Portuguese	8.0 mm. (.315 inch)—410
Swedish	8.0 mm. (.315 inch)—393

If the whole ballistic qualities, or "goodness," of the rifles could be relied upon under all circumstances, then the classification shown in the above table would be correct. As a matter of fact, however, several of these military rifles have their weak points, either in connection with the breech action, or the magazine, or in connection with the ammunition. In order, therefore, to ascertain their practical as distinguished from their theoretical "goodness," it becomes necessary, in some cases, to make deductions from their performances under the most favorable conditions. In Professor Hebler's opinion, the English, Swedish, Russian, Austrian, Bulgarian and Swiss rifles are those least to be depended upon, and he consequently makes a deduction of 10 per cent. to allow for their minor defects, whilst he credits all the others with their full ballistic qualities. He thus ranks the rifles into three classes: the first class, including those whose "goodness" exceeds 500; the second class, those whose "goodness" lies between 400 and 500; and the third class, those whose "goodness" falls below 400.

FIRST CLASS.

Spanish	.283 inch—580
Belgian	.299 inch—516
Turkish	.299 inch—516

SECOND CLASS.

Russian	.299 inch—486
German	.311 inch—474
English	.303 inch—469
Swiss	.295 inch—467
French	.315 inch—433
Danish	.315 inch—411
Portuguese	.315 inch—410

THIRD CLASS.

Austrian	.315 inch—396
Bulgarian	.315 inch—396
Swedish	.315 inch—354

From the above it will be seen that the three improved Mausers hold the first places, both from their theoretical and from their practical ballistic qualities; and it appears probable, therefore, that most of the European States, when they decide on re-armament, which they shortly will be obliged to do, will adopt improved Mausers of still smaller calibre.

MECHANICAL DEVICES AND OPERATIONS EMPLOYED IN SEATING A 13-INCH JACKET WHICH STUCK IN THE OPERATION OF BEING SHRUNK ON.

The following description of the method which was recently used with success to seat the jacket of a 13-inch gun, which had stuck in the operation of being shrunk on, was prepared by Ensign A. L. Key, U. S. Navy, and is published by permission of the Bureau of Ordnance.

The theory of the method, as indicated by the Chief of Bureau, was "that, by rapidly cooling the inside of the tube, the average difference of temperature between the tube and jacket could be made considerable, and the inner portion of the tube would contract and draw the outer portion away from the jacket. The surfaces of the tube and jacket in contact would, of course, always be at the same temperature. Experience in this case shows that an actual separation of the tube and jacket furnishes the only certain test as to the time when such a tube and jacket can be assembled. The object in supporting the weight of the tube by the crane, before turning on the water, was to prevent the tube from moving before the maximum separation had taken place; otherwise the galling would have been increased, and it would have been still more difficult to assemble the parts."

This jacket was shrunk on the tube on the 7th of December last. It was placed in the furnace on the morning of December 6 and heated till 4.30 P. M., of that day, when the blast was turned off for the night and again turned on at 8.00 A. M., the 7th.

A temperature of about 600° was maintained in the furnace.

The jacket was given the usual expansion, something more than 0.″07, the shrinkage being 0.″027. The outer surface of the tube and the inner surface of the jacket were smooth, excepting about two feet of the rear end of the latter was slightly rough.

The jacket was lifted from the furnace about 3.00 P. M., the 7th, temperature at top 511, at bottom 558, lowered over the mandrel, which was 0.″02 larger in diameter than the greatest diameter of the tube, and then lowered over the tube. It went on smoothly until about 18″ from its seat when it began to gall. The crane was reversed as soon as possible and the jacket pulled off about 2.″5 when it stuck and brought the tube with it.

The gun was immediately lowered, the set screws in the pit tightened and another attempt made to pull off the jacket, but it again brought the tube with it.

The gun was then allowed to cool.

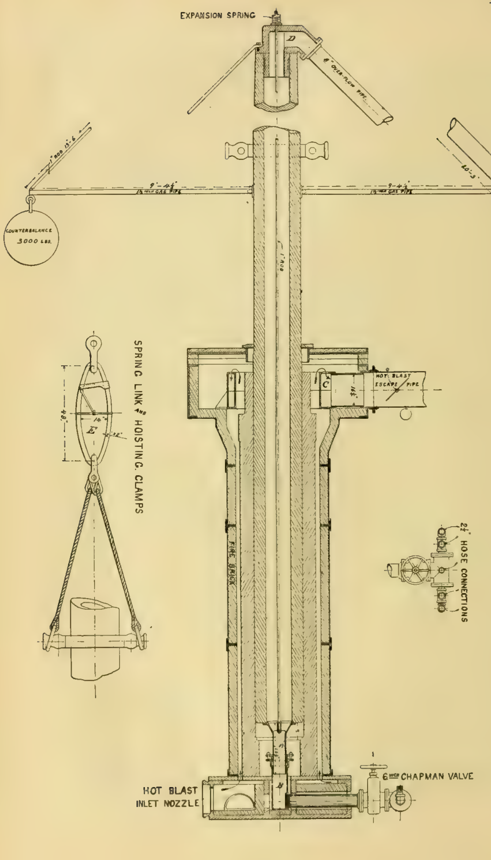
On investigation, the jacket was found to have stuck 12.″16 from its seat, there were two galls at the rear end of the jacket, each about 0.″5 wide and 0.″025 deep, and two galls on the tube forward of the jacket, each 2.″5 long, about 0.″2 wide and 0.″02 deep.

The following preparations were made under the direction and supervision of Captain W. T. Sampson, U. S. N., for getting the jacket in its place:

The gun was put in a lathe, the forward face of the jacket turned off 0.″1 and a fillet turned on the inner edge of the forward face. The furnace was made ready to receive the gun, breech down, the top altered, and asbestos packing used to make an air-tight joint around the jacket. January 16, the gun was placed in the furnace, breech down, the rear face of the jacket resting on the iron bottom.

Water connection was made with the breech end of the tube, as shown in the accompanying sketch, marked *A* (not shown).

Asbestos packing was used at the joint between the pipe and the tube. Water connection for the overflow pipe at the upper end of the tube was made, as shown in the sketch, marked *D*.


EXPANSION SPRING
D
8" OVER-FLOW PIPE
1" ROD 15'-6"
9'-4½"
1½ INCH GAS PIPE
COUNTERBALANCE 3000 LBS.
1" ROD
SPRING LINK AND HOISTING CLAMPS
E
C
HOT BLAST ESCAPE PIPE
FIRE BRICK
2½" HOSE CONNECTIONS
B
HOT BLAST INLET NOZZLE
6 INCH CHAPMAN VALVE

The overflow pipe was counter-balanced by a weight of 3000 lbs., as shown in the sketch. A long wooden arm, not shown in sketch, was attached to the tube about four feet above the jacket.

It rested on a knife edge near the tube, so that the outer end exaggerated any vertical movement of the tube in proportion of about 25 to 1. A spring link E was made, tested and marked so that the pointer would indicate when it bore a weight of 33,000, 42,000 and 57,000 lbs.

The weights of tube and jacket were 44,000 and 38,000 lbs., respectively. At 8.00 A. M., January 19, started to heat furnace and maintained a temperature between 600° and 650° until 2.30 P. M. the 21st, when preparations were made for turning the water through the tube. A piece of lead, melting point 600°, was lowered by a wire to the bottom of the tube, where it melted.

The crane was attached to the clamp on the tube and a gradual strain put upon it until the pointer showed a strain of 57,000 lbs.

At 2.45 the water was turned on full head through the tube and the pointer in the spring link closely watched to see if it changed position, which would indicate that the tube in rapidly cooling had contracted away from the hot jacket until disengaged from it, relieving the crane of about one third of the strain.

The pointer did not change its position, though an opening of about 0.″03 was observed between the tube and forward end of jacket, but on one side only, the tube not standing strictly vertical.

After the water had been going through the tube about thirty minutes the crane was relieved of its strain, but the tube did not move. After several more attempts, the experiment was finally abandoned for the afternoon. The water was turned off and the heat turned on the furnace, maintained during the night and the next day until about 3.30 P. M., when the water was again turned on the tube, the crane taking a weight of 57,000 lbs., as before.

After the water had been going through the tube for twenty-three minutes, though there had been no movement of the pointer in the spring link, the crane was relieved of the strain, and the tube went down 4.″62, leaving it 7.″54 from the shoulder of the jacket.

The cooling of the tube was continued and further attempts made by taking and relieving the strain on the crane, but without success. The gun was allowed to cool and was taken from the furnace January 25, placed in a lathe, and the rear end of the jacket faced off so as to make the tube stand vertical.

It was found in the foregoing experiments that the furnace had not equally heated all parts of the jacket so that the pipe C with openings on the upper side was cast and placed in the furnace to force the hot air to distribute itself equally on all sides of the jacket. Before this arrangement the draft to the chimney was on one side of the furnace. As the slip joint A had leaked considerably when the tube went down, and as the pipe and packing prevented the extreme lower end of the tube from being cooled as rapidly as the other portions, the water connection, with the bottom of the tube, was changed, as shown by the sketch marked B.

Asbestos packing was used at the juncture of pipe and tube, and a stuffing box and piston packing used for the slip joint between the two pipes.

The long one inch rod through the centre of the tube, with a spring at the top to allow for expansion and contraction, served to keep both water connections in place. The top of the furnace was raised a few inches to allow a more thorough heating around the upper end of the jacket. The other conditions were the same as in the previous experiments. The gun was placed in the furnace, breech down, the tube standing vertical. February 17, the hot blast was turned on and for seventy-two hours a temperature between 600° and 700° was maintained.

At 2.00 P. M., February 21, the crane was attached to the tube and a strain of 57,000 lbs. placed upon it; the hot blast was turned off, the water turned on full head and after thirteen minutes, a slight opening showing between the upper end of the jacket and tube, though there was no movement of the pointer in the spring link, the crane was relieved of its strain and the tube went to its seat.

In the foregoing experiments, when the water was turned on, there was a slight ebullition of steam for about fifteen seconds, after which the temperature of the water was raised only between 5° and 10°, and rapidly fell until the difference of temperature before entering and after leaving tube was less than 1°.

A NEW SYSTEM OF COMPASS CARDS OF SMALL WEIGHT.

By Dr. P. J. Kaiser, Chief Inspector of Nautical Instruments of the Netherlands Navy.

[Translated from the *Revue Maritime et Coloniale*, February, 1893.]

In order that compass cards may be used with confidence on board ship, they must satisfy conditions, both theoretical and practical, which have only been known during the past few years.

The object of the card is to indicate magnetic north with accuracy, under whatever conditions the ship may be placed. Unfortunately, these conditions are often so unfavorable that most known forms of compasses fail to accomplish this end. Theoretical research on shore and practical experiments on board ship have taught that, in the construction of compass cards, the following conditions must be fulfilled:

1. The quotient obtained by dividing the magnetic moment of the card by its weight should be as great as possible.
2. The quotient obtained by dividing the moment of inertia of the card about a central axis perpendicular to its plane by its weight should be as great as possible.
3. The card should be as light as possible.

The existing light cards satisfy the two last conditions well enough, but by the sacrifice of directive force. It is evident that a compass card having a very small directive force will be easily disturbed in its indications by the friction on its pivot and against the surrounding air in the bowl, and by still other causes. This fault is the more troublesome on board iron ships in situations where the earth's horizontal force is in great part neutralized by the induced magnetism of the neighboring soft iron. On board iron ships, therefore, it is desirable to use cards of great magnetic moment.

To overcome the defects of the existing light-weight compass cards, I have designed a card which, to my mind, satisfies the three conditions above mentioned, and which has, moreover, the advantage of being very inexpensive.

A piece of silk on which a compass rose is lithographed is secured around its edges between two rings, each of which is made partly of steel and partly of copper ribbon of the same size.

If this is properly done, a perfectly circular hoop covered with silk is the result. The steel parts, after having been magnetized, form the actual magnetic needles of the card. The copper parts should be of such length that the poles of the magnets of the exterior ring are separated by an angle of 26°, and those of the interior ring by an angle of 96°. The north and south line of the card should naturally bisect the angles

between the poles of the circular magnets exactly. In the centre of the card is a cap fitted with a sapphire. The card is magnetized in the ordinary way by the aid of an artificial magnet.

After magnetization, the card has in each of the two rings two north and two south poles, separated as mentioned above ; there are, therefore, eight magnetic poles so placed that Evans' theory regarding magnetic needles of great length is completely satisfied.

If the directions laid down by Evans are departed from, it is well known that the correction of large quadrantal deviations gives rise to sextantal, octantal and decental deviations, if soft iron is used at small distances from the compass, which is a necessity because the quantity used would and should be somewhat limited.

It is unnecessary to say that, however simple the construction of the card, as described above, may seem, practice is required to make it properly. For example, the silk disc should not be stretched, for the cloth shrinks under the influence of heat, and the rings will be deformed if the silk has not sufficient play. Again, the rings must be placed a little below the point of rotation of the card in order that the moments of inertia with reference to all axes may be the same. Remembering that the specific gravity of copper, even when rolled under heavy pressure, does not differ much from that of steel, it will readily be seen that, as a consequence of the construction of the card, its moments of inertia about any axis in the plane of the card must be equal.

In order to render the silk less sensible to the influence of the moisture and changes of temperature, it is coated with paraffine and then treated with a preparation which restores to the too transparent coated silk a dead white, non-transparent appearance.

The following table, the data for which are taken from the work of the *Deutsche Seewarte*, Hamburg, *Der Kompas an Bord* (page 43), gives a comparison of these cards with those of Thomson, Hechelman, and others, as far as regards the three conditions mentioned above :

System.	*Maker.*	*Diameter in millimetres.*	*Weight in grams.*	*Magnetic moment divided by weight.*	*Moment of inertia divided by weight.*	*Time of one oscillation in seconds.*
Thomson.	White.	254	12.0	0.157	10.38	19.1
Thomson.	Harry.	250	13.4	0.232	9.65	15.2
Thomson-Ludolf.	Ludolf.	252	20.5	0.097	7.95	21.2
Hechelman.	Hechelman.	255	42.6	0.166	10.97	19.2
Hechelman-Thompson.	Hechelman.	255	16.5	0.273	13.57	16.5
Dr. P. J. Kaiser.	Olland.	246	16.5	0.476	13.27	12.4

It will be noted that these cards exceed in directive force, and that their moment of inertia divided by their weight is nearly equal to that of the greatest while the weight itself is very small.

[NOTE BY TRANSLATOR.—Dr. Kaiser continues his article by comparing the cost of his card with that of cards made on other designs, claiming that the latter are, at least, twice as expensive ; and gives extracts from a number of favorable reports made by different sea captains upon the use of his card under different circumstances. Captain Harten, of the Netherlands steamer Prinses Amalia, reported that he had replaced the compass card in use on the forward bridge by a Kaiser card while the ice machine was in operation, and the oscillations, which had ranged from 6 to 8 points, were at once reduced to ¼ to ½ of a point. The card has been adopted in the navy of Holland, and has been found eminently satisfactory, notably on board the first-class torpedo-boat Habang. Dr. Kaiser considers that the satisfactory use of his card on a torpedo-boat is an excellent test of its merits, and with reason.]

PHOTOGRAPHING FLYING BULLETS.

[*United States Gazette*, May 6, 1893.]

At the Royal United Service Institution on Friday, April 28, Sir Frederick Bramwell presiding, Professor C. V. Boys, of the Royal College of Science, gave a lecture, illustrated by photographs and experiments, on "The Photography of Flying Bullets by the Light of the Electric Spark." The lecture was of a highly technical character, and consisted largely of explanations and elucidations of the numerous photographs, nearly thirty, in which the experiments were recorded. Professor Boys alluded to the various methods of obtaining photographs of moving objects traveling at a high rate of speed, such as the rapid-shutter system, in which the eye of the camera is only allowed to see through a small aperture for a moment, and the magnesium flash. But neither of those sufficed to give a sharp picture of a bullet *en route* at an ordinary rate of speed. Nor would the electric spark be of much use in photographing the bullet of a magazine rifle passing along at the rate of about 2100 feet in a second, or about 1400 miles an hour. The result was found to be a mere blur, the spark lasting so long that the bullet was actually able to travel half an inch or so while the illumination lasted. Mr. Boys, therefore, set himself the task of manufacturing an electric spark which, while it gave light enough to act on the plate, lasted so short a time that even a rifle bullet could not move an appreciable distance during the time it was in existence. This he accomplished by using a revolving mirror made of hardened steel, and capable of running round at the rate of 1000 turns a second. The light from the spark was focused by the mirror upon a photographic plate while revolving at the rate mentioned, equivalent to about 160,000 miles per hour, or 200 times faster than the speed of a Maritini-Henry bullet. In this way, as Professor Boys illustrated in detail, perfectly sharp photographs of flying bullets were obtained. Professor Mach, of Prague, first accomplished the feat by means of a specially contrived electrical apparatus, and succeeded in photographing the air waves caused by the bullet in its flight. Professor Boys believes his apparatus to be of a simpler kind than that adopted by Professor Mach. A photograph of the apparatus was shown, but a mere description of it would be illusory and uninteresting. One of the photographs showed a bullet just as it had left a Maritini-Henry rifle. It appeared perfectly sharp, and there was no sign of any movement, so far as the bullet itself was concerned, but there were distinct evidences of the presence of air waves. These waves were much more conspicuous in another photograph of a bullet from a magazine rifle going along at the rate of 2000 feet per second. The waves were more inclined to a vertical inclination than the others, and the lecturer gave an elaborate explanation of the reason why the inclination of the waves varied with the rate of speed. These waves, revealed by photography, have a very important effect on the flight of projectiles, and the illustrations exhibited created much interest. In order to test the analogy between air waves and water waves, and to see whether the former could impede the progress of a bullet, in the same manner, though in different degree, as the latter affect the motion of a ship, the lecturer arranged three reflecting surfaces of sheet copper, and photographed the result of the air waves striking against them. From these experiments he concluded that the reflection or non-reflection of air waves produced by a passing bullet when meeting with a solid body might bring about important results. Professor Boys also described experiments in which he sought to ascertain what proportion of the velocity of a bullet was given to it after it had left the barrel, and the action of a choke-bore upon a charge of shot. Another very

interesting series of experiments was detailed, showing the process of a bullet piercing a glass plate from a first shock, step by step, until the bullet had escaped out of the midst of the disaster and confusion it had created. The lecturer concluded his task amidst the hearty applause of his audience.

Some interrogatory remarks were made by Colonel C. H. Scott, Mr. Rigby, Colonel Fosberry, Captain Straker and Captain Acland; and Sir F. Bramwell, observing that such experiments would, even but a few years ago, have been regarded as impossible, tendered the thanks of the meeting to Professor Boys for his unique lecture.

ENGINE-ROOM ARTIFICERS.

[*United Service Gazette*, April 1, 1883.]

The anomalous position held by the engine-room artificers and the undoubted grievances under which the class labors have frequently been referred to in the columns of the *United Service Gazette*. The concessions now asked for are of so reasonable a nature we cannot think but that they will be granted in the near future. A fresh statement of their claims to the following effect has been circulated by the engine-room artificers amongst members of Parliament and others. It is commendable for its moderation:

The engine-room artificers of the Royal navy, it states, are a class of mechanics privately trained in the necessary respective engineering trades at their own parents' expense on shore, and when fully qualified as workmen, they are entered in the Royal navy to execute the skilled mechanical work in the engine and boiler-rooms of Her Majesty's ships of war; in addition to which they have also now to perform similar duties to that of junior engineers, such as keeping watch in either engine or boiler-room. In fact, they are not even retained in the Royal navy, or receive any rise of pay, until they obtain from their own immediate superiors, the engineer officers, certificates (approved by the captain of their ship) of competency in those particular duties.

The class was introduced into the Royal navy as an experiment by an Admiralty Order in Council, March 28, 1868, and proving a success, the Lords of the Admiralty under different administrations permanently established it in the naval service of the country, and very largely increased its numbers, with a corresponding decrease in those of the junior engineers, and artificers are now sent to ships in lieu of such commissioned officers.

Since the establishment of this class everything connected with engineering science has gradually become more complicated, and of necessity requiring greater skill and attention on their part, and the recent reduction of mechanical skill in the engine-room complements of Her Majesty's ships has placed more arduous labor and greater responsibilities than ever upon the engine-room artificers. A large number are now placed in sole charge of the machinery of small ships, torpedo-boats, etc., with all the men in the engine department under their management and control. They have also to keep the stores and necessary books connected therewith, and yet their status is still but that of a petty-officer—a similar rank to that of many of the men who work under their instructions. In the interest and for the well-being of the naval service, and to carry out our necessary discipline, they ask very humbly that chief engine-room artificers be placed in an equivalent rank with warrant officers, and that engine-room artificers with six years' service should rank with but after warrant officers, with their privileges, and be entitled engineer artificers. An

engine-room artificer relieves an engineer officer in his watch and performs similar duties; the latter is a commissioned officer, whilst the engine-room artificer and leading stokers who work under his orders are both petty officers. The rank of warrant officer would be a sort of intermediate one for them between the before-named commissioned officer and ordinary petty-officer.

They also ask that their mess place should be greatly improved, and invariably carried from deck to deck. As a general rule it is on the lower deck, a bulkhead breast high, in some cases of iron plates, and not the least isolated, but often in very exposed places. They also request that in all ships a separate wash place should be provided for the engine-room artificers, to prevent as far as it can be carried out, their association with the stokers. This would greatly add to the discipline of the navy and stop a great deal of unpleasantness and a grievance to which they are at present subjected. . . . .

It is pointed out that any proposal to increase the number of chief engine-room artificers is not of the least advantage to the class in general, as it is an impossibility for the majority of them even to obtain this rating; if it were possible, it would not in the slightest remove the disability under which they as a class of naval mechanics labor, and would not be of any advantage whatever to any man except as regards his obtaining a little more pay. His position on board a ship—that of a chief petty-officer—is precisely the same as it was before he received the higher rating.

In asking for their position to be improved from chief petty-officers to that of warrant officers, with similar privileges, the engine-room artificers are fully aware of the difficulties that beset such an arrangement and change, and of the plea that the limited accommodation for cabins on board Her Majesty's ships prevents such a step being taken on their behalf; but they would most humbly draw attention to the following table, which shows their exceptionable position compared with that held by other departments in the same vessel in which they may be serving.

Gunnery Department.	*Navigating Department.*	*Carpentering Department.*	*Engineering Department.*
Gunnery Lieutenant, Commissioned Officer.	Staff Commander, Commissioned Officer.	Commander, Commissioned Officer.	Chief Engineer or Engineer, Commissioned Officer.
Chief Gunner, Rank with Sub-Lieutenant.	Chief Boatswain, Rank with Sub-Lieutenant.	Chief Carpenter, Rank with Sub-Lieutenant.	
Gunner, Warrant Officer.	Boatswain, Warrant Officer.	Carpenter, Warrant Officer.	
Chief Gunner's Mate, Chief Petty Officer.	Chief Boatwain's Mate, Chief Petty Officer.	Chief Carpenter's Mate, Chief Petty Officer.	Chief Engine-room Artificer, Chief Petty Officer.

From the above it will be seen that there are two intermediate steps between the commissioned or ward-room officers in all departments except the engineering, where there is no gradation of rank between a commissioned officer and a chief petty officer. In some cases, even in large vessels, the only engineer officer on board has fallen sick, and then the whole responsibility and onerous duties of the engineering department have fallen on the senior engine-room artificer. All persons conversant with the routine of the Royal navy, or duties on board a man-of war, well know the great chasm between the commissioned officer and petty officer, and the engine-room artificers only ask for the intermediate or similar rank of warrant officer in the engineering department. In point of accommodation they do not ask for a separate cabin for each engine-room artificer, similar to the gunner, boatswain or carpenter; far from it, such is not

their wish or desire; but they humbly ask for an enclosed mess berth, carried from deck to deck, instead of the present arrangement now fitted for them, about three or four feet high. The argument has been used that the mess berth, if carried to the deck, would interfere with the ventilation of the ship. This remark will apply to every cabin in the vessel, so that one more will not make any material difference in that respect. They further represent that in their present so-named mess berth fire hoses are, in some cases, stowed over their heads and shot under their feet, and that often the seamen hang their hammocks and sleep over their heads. When the ship is under steam the engine-room artificers require a resting place between their watches; this is now denied them by the present mess berth. In all cases, a bath and washing arrangements separate from the stokers should be fitted. The pensions of the class are not at all in proportion to their pay, as compared with other classes. They ask to have them increased to £3 15s. per annum for each year's service as chief engine-room artificer, and £3 10s. for each year as engine-room artificer. This would not effect the estimates (to any extent) for some years to come.

CORDITE.

[Reprinted, by permission, from the lecture of Lieut.-Col. F. W. J. Barker, in the *Proceedings of the Royal Artillery Institution*, May, 1893.]

Cordite.	Nitro-Glycerine,	58.
	Gun-cotton,	37.
	Mineral Jelly,	5.

Comparative Table Showing Dimensions of Cordite at Present Used.

The thicker cordite, size 20 and upwards, is cut into lengths of 14 inches, and used in bundles of the required weight for the charge.

Cordite for field guns is 11 inches long, and the S. A. rifle charge is made up of 60 strands, or threads, of suitable length for the cartridge.

We have now examined the outlines of the methods employed in the manufacture of modern powders, and some of the processes which have been adopted to render them reliable propellants with the various guns in our service. The next step, or rather leap, in this manufacture to be considered is the introduction of smokeless propellants. We are all aware how, for many years, this has been the ambition of the artillerist and the study of the chemist. It is hardly necessary to remind Officers of the Royal Artillery of the failures in this direction, which, for more than three decades, frustrated the efforts of those who tried to obtain a smokeless powder for rifled guns and small-arms. Gun-cotton in every form, picric acid in various conditions, and many tri-nitro and di-nitro compounds were experimented with, confidently at first, then hopefully, and apparently finally abandoned in the face of what seemed to be insurmountable difficulties. At last, however, a sudden impetus was given to the whole question, about seven years ago, by recent discoveries in chemistry, and by the supreme importance which the introduction of quick-firing guns and magazine rifles gave to the production of a powder which would not, by its smoke, utterly neutralize the benefits to be obtained by rapidity of fire. Most of us remember that many years ago smokeless powder was considered to be a possibility within reach, when the character of gun-cotton was first recognized, and it was thought that this substance might be utilized by being kept under control or "tamed" by some retarding agent. To the unscientific but practical man this seemed a matter not difficult to accomplish. On the one hand, we have a violent explosive of good gas producing powers and almost unlimited energy; on the other, an almost boundless range of dilutants, retarding agents, or "tamers," which, in greater or less quantities, should at any rate bring the violence of the explosion of gun-cotton to the same level as that of gunpowder. Here then, at first, was the problem to solve: To use with gun-cotton such a retarding agent as will "tame" the explosive, make it safe to handle, store and use, and at the same time leave it with sufficient energy for use in modern guns and rifles with certainty and regularity of propulsion. This problem, simple as it appears, baffled, for decades after gun-cotton was known, the energies and knowledge of the most scientific artillerists and chemists; and it is only within the last few years that any real approach to success has been made, and this success has been chiefly due to the use in the right direction of one of the properties which gun-cotton exhibits, namely its solubility in acetone.* The solubility of gun-cotton in acetone has been known for a considerable time; but how to utilize this property for artillery purposes has only recently been discovered, and is still the subject of careful investigation. Again, in January, 1888, Messrs. Nobel & Co. registered a patent of the discovery that nitro-cellulose could be mixed with nitro-glycerine and that the two so combined, with or without the addition of a retarding agent, form a substance which can be relied upon for ballistic purposes. This, with other discoveries made about the same time, may be considered as practically the starting point for the most valuable of the smokeless

*Acetone, or "dimethyl-ketone," $CH_3CO\ CH_3$, or "pyro-acetic spirit," is obtained among the products of distillation of wood, and may be prepared by distilling the acetate of lead calcium or barium.

The crude distillate is shaken with a saturated solution of hydrosodium sulphate, which combines with acetone to form a crystalline compound $(CH_3)_2\ CO.HNa\ SO_3$. This is freed from the mother liquor and distilled with sodium carbonate, when acetone distils over mixed with water, which is removed by fuzed calcium chloride.

Acetone is a colorless, fragrant liquid, Sp. gr. 0.81, and boiling at 56.3 C. = 133.3 Fahr. It is inflammable, burning with a luminous flame. It mixes with water, alcohol and ether. —*Bloxam's Chemistry.*

powders, and those most largely used in the services, both in England and on the continent of Europe.

As cordite is composed of two "high explosives," gun-cotton and nitro-glycerine, the means adopted for converting them into a reliable propellant have now to be considered.

"High explosives" have all, more or less, the characteristics to which they owe their title. These are, great sensitiveness under certain conditions, and liability to violent explosiveness or detonation in their ordinary or "untamed" condition.

One can well understand that none of these substances untamed are suitable for use with arms of precision. Under certain circumstances they might give fair shooting and satisfactory results; and under others their violence might be productive of the most serious consequences. A reliable retarding or "taming" agent was therefore absolutely necessary, and by using a solvent, such as acetone, and reducing gun-cotton to a plastic mass and then adding an inert or "slowing" substance, either a resin, grease, or other material, this violent explosive has been tamed down to any degree of rapidity of combustion required.

Gun-cotton has, however, one serious drawback, and that is that even with the highest degree of explosiveness which can be permitted for safety, it does not produce a satisfactory proportion of permanent gases during combustion, and the pressures developed are too high in comparison for the velocities obtained with the projectiles. We are therefore obliged to introduce some other ingredient which, while not producing smoke, will evolve the necessary gases for propulsion of the projectile, without increasing the rapidity of combustion or involving the risk of detonation. All manner of inert substances have been tried for this purpose with more or less success, but none as yet have been perfectly satisfactory. I may say, however, that a near approach to a gun-cotton smokeless powder was made at Waltham Abbey some years ago, when a grained powder was produced which, while smokeless, gave the best shooting obtained up to that time. Just at this period, however, the discoveries previously referred to were developed, namely, that an *active* agent could be used with gun-cotton, and nitro-glycerine combinations rapidly took the field.

The strange anomaly of two of the most violent explosives known, nitro-glycerine and gun-cotton, when combined in nearly equal proportions, producing a moderate explosive under control was, as I have already said, the starting point of a new era in smokeless powders. Nitro-glycerine is, as we know, about the most violent explosive yet discovered, gun-cotton is also noted in the list of "high explosives." Both when separate are very sensitive and easily detonated; but when combined they burn with great regularity.

I have now briefly mentioned the two great classes of smokeless powders; first gun cotton and its kindred chemical compositions with a retarding agent, and, second, gun-cotton combined with nitro-glycerine where nitro-glycerine takes the place of the retarding agent which was formerly used with gun-cotton. The first has not been so successful for the reasons already given, while the latter (gun-cotton with nitro-glycerine) gives most excellent ballistics but very high temperatures. The excessively high temperature which is produced by the use of nitro-glycerine has contributed towards the continuation of investigations on the Continent, as to the possibility of obtaining a gun-cotton or other smokeless powder; but hitherto we have not heard of any marked success.

I think that we are now in a position to discuss the manufacture of the smokeless powder, cordite, which promises so favorably, and which has been made so successfully in large quantities for over a year at Waltham Abbey.

Cordite is a smokeless propellant of the combined nitro-cellulose (or

gun-cotton) and nitro-glycerine type. Its composition was determined by a committee (The Explosives Committee) of most distinguished chemists, with Sir Frederick Abel as president. They decided that the proportion of the ingredients should be gun-cotton, 37 per cent.; nitro-glycerine, 58 per cent.; and mineral jelly, 5 per cent. The gun-cotton is first dried (in the form of 9-ounce primers) down to about 1 per cent. moisture. Then a portion ($27\frac{3}{4}$ lbs.) is placed in a brass-lined box, and $43\frac{1}{2}$ lbs. nitro-glycerine are carefully poured over it. These ingredients are then carefully mixed by hand and taken to the incorporating machines, and the whole is brought into a gelatinous condition by the addition of about $15\frac{10}{16}$ lbs. of acetone, which is poured over the charge in the incorporating machine, and worked up into a kind of dough. $3\frac{3}{4}$ lbs. of "mineral jelly" * are afterwards added, and the material is incorporated or mixed for seven hours. When it has been sufficiently incorporated and is ready, the charge is taken to the press house where it is squeezed in a cylinder, one end of which has a small hole of the required size for the cordite, which is sqirted through by means of a plunger or piston pressing on the other end of the cylinder. The cylinder is filled with composition and the plunger pushes or squirts the soft material in the form of cord or string of the thickness required. The sizes are .0375 in., which is used for the rifle, up to .5 in., which has been experimentally used with a heavy B.-L. gun with satisfactory results. This string is wound on reels for the smaller, or cut into lengths for the larger natures. It is then placed in a stove and is dried, to get rid of the acetone, at 100 degrees Fahr., from three to nine days, according to the thickness of the cordite. It is afterwards blended in the rifle cordite, by taking the production of ten presses which are on "one strand" reels and winding these on to one "ten strand" reel. Then the cordite on six "ten strand" reels is wound on to one drum, which make up a rope or cord of 60 strands, which in short lengths form the $30\frac{1}{2}$ grain charge of the magazine rifle. The larger natures of cordite are blended on the same principles as gunpowder. Cordite has proved itself to be very safe to manufacture in its later stages, *i. e.*, *after* incorporation, and although we have had slight ignitions, I am glad to say that no explosion of any consequence has occurred.

Having now briefly sketched the outline of the manufacture of cordite, we will turn to what is doubtless the more interesting portion of the subject to practical gunners, namely, what are its shooting properties, its keeping qualities, and what is the effect of using it in the guns and small-arms with which it is employed.

Shooting Qualities.

First, as to its shooting qualities, we can best judge of them by actual results obtained, and by comparison with our old friend black powder in the same weapon. These results, which are shown in the table before us, speak for themselves. I owe the latest results to the kindness of the Director-General, Dr. Anderson, and to our friends at Waltham Abbey. I have here sketched a comparative table, showing the results obtained by black powder and smokeless powder. The black powder is in Roman type and smokeless powder in black type, and I think that, without any further demonstration, we can see for ourselves the great advantages to be obtained if the smokeless powder always does what the table before us indicates. First we have 30 grains of the smokeless powder giving a 2000 feet velocity, as against 70 grains of the best of the

* Mineral jelly (vaseline) is the liquid which distils over from petroleum at temperatures above 200 C. It is a hydrocarbon, richer in carbon than petroleum, and boils at about 278 C. Formula $C_{16}H_{34}$.

modern black powders giving 1830 feet velocity, + or — 40. Then, in the field gun (which most of us here are interested in) one pound and half an ounce of smokeless powder (cordite) must give, as a condition of accept-

Comparative Results.

Cordite and Black.

Nature.	Charge.	Velocity.	Pressure.
Magazine Rifle.	70 grs.	1830 ± 40	18
do.	**30 grs.**	**2000 ± 40**	**15**
12-pdr. B.-L.	4 lbs.	1710 ± 20	15
do.	**1 lb. 0½ oz.**	**1710 ± 20**	**15**
4.7-in Q.-F.	12 lbs.	1830 ± 30	16 to 17.6
do.	**5 lbs. 7 ozs.**	**2145 ± 25**	**15**
6-in. Q.-F.	29 lbs. 12 ozs.	1890	15
do.	**14 lbs. 3 ozs.**	**2274**	**15.2**

ance for service, 1710 feet + or — 20, as compared with 4 lbs. S. P. (selected pebble), which gives 1710 f. s. Then quick-firing gun, the 4.7-inch, gives, with 12 lbs. black pebble, 1830 feet + or — 30, while with 5 lbs. 7 ozs. of smokeless powder it gives 2145 feet + or — 25. I think those results speak for themselves. Then again, in the 6-inch gun, 29 lbs. 12 ozs. of black powder giving 1890 feet muzzle velocity with 15 tons pressure. The results in the table are based upon actual shooting, and the conditions of acceptance are framed upon practical experience, and these conditions must be complied with by all powders before they are allowed to pass into the service. It may here be interesting to quote some of the actual shooting within the last few months of our own experience, and for these, the latest results, I have again to thank our friends at Waltham Abbey, and also the Director-General, who has kindly permitted me to have them. With lot 8, size 5* (that is, field gun size) in the 12-pdr., 1 lb. 0½ oz. charge, from the actual results fired in July last we obtained 1732 feet as the muzzle velocity with 13.84 pressure. The results which were forwarded to me last month were 1726 feet velocity with the same lot, and 13.45 pressure. The temperature of the air when the firing took place in December being quite sufficient to account for the slightly lower results as compared with those obtained in July. It is easy to understand the favorable impression that results of this nature make upon those who watch them carefully. Then there are other difficulties which had to be contended with, and one was technically termed "sweating," which frequently causes strained relations between employers and employed (or unemployed?). Our "sweating," however, had nothing to do with workmen, but it was a curious propensity which some batches of cordite exhibited in exuding the nitro-glycerine on the

*Size 5, lot 8, fired at Woolwich, 7 July, 1892, in 12-pdr. B.-L. gun, charge 1 lb. 0½ oz.

M. V.	Mean.	Pressure.	Mean.
1734		13.3	
1731		14.2	
1733	1732	14.1	13.84
1733		13.8	
1728		13.8	

surface. There are various causes which produce this exudation, one of which is water in the nitro-glycerine before incorporation; there are also several others which we need not enter into here, but I believe that the difficulty has been completely overcome by arrangements during manufacture.

Climatic Trials.

Secondly, as to climatic trials or keeping qualities. Climatic trials have been carried out all over the world, and they have so far proved eminently satisfactory. The arctic cold of the winter in Canada with the temperature below zero, and the tropical heat of India have as yet failed to shake the stability of the composition, or abnormally injure its shooting properties. The Director General kindly wrote to me the other day and said that cordite returned from Canada has been analyzed, and has been quite unchanged. I have myself had under my own observation 100 lbs. in an open case, exposed, in an open porch, to all the vicissitudes of a Waltham winter—snow and rain—and also to an English summer—rain without the snow—and the results again showed that there was hardly any perceptible difference in shooting due to this severe test. If our old friend pebble or prismatic powder had half this ill-treatment one would have wished for a sea range, and a clear one, to fire over, and should certainly have protested against ordinary proof within twelve miles of London.

Thirdly, the effect on the weapon.* This may perhaps, and indeed is likely to prove the weakest point in the use of cordite under certain conditions. The small-arm magazine rifle undoubtedly suffers in the bore from the great heat evolved and the high velocity imparted to the projectile. On the other hand, we have at Waltham Abbey a 4.7-inch quick-firing gun which has fired, up to September last, over 40 rounds of black and 249 rounds of cordite, and yet the bore shows no abnormal erosion or scoring. We have also a 12-pdr. B.-L. constantly used, up to the same date, for firing pebble and cordite, and the bore is as smooth as could be expected.

In conclusion, we must all remember that, although smokeless powders have developed so rapidly, and have shown such great suitability for the guns with which they have been used, they are still in their infancy, and have not yet been subjected, on any large scale, to the stress of active operations in the field, engagements at sea, or lengthened storage in average magazines. So far as our experience goes, however, the results have been eminently satisfactory with our own smokeless powder, CORDITE.

*Since writing the above, the lecturer has been informed that in the .303 magazine rifle this difficulty has been almost overcome by the use of a suitable wad.

BOOK NOTICES.

INDEX TO THE LITERATURE OF EXPLOSIVES, PART II. By Charles E. Munroe, late Chemist to the Torpedo Corps, U. S. Navy. Deutsch Lithographing and Printing Co., Baltimore, 1893. Subscription price, in paper, $1.00.

In Part II. of his Index, Professor Munroe carries on his valuable reference list of articles bearing upon explosives that have appeared since the publication of Part I. in 1886, and in addition gives references to Dingler's Polytechnisches Journal, Nicholson's Journal of Natural Philosophy, Edinburg Journal of Science, Popular Science Monthly, Proceedings American Chemical Society, and Brande's Journal of Science and Arts.

His researches have been carried through nearly one thousand volumes, and include the following named periodicals, besides those mentioned above: American Journal of Arts and Sciences, Philosophical Transactions of the Royal Society, PROCEEDINGS OF THE U. S. NAVAL INSTITUTE, Revue d'Artillerie, Journal of the Royal United Service Institution, and Reports of H. M. Inspectors of Explosives. The two parts of the Index are believed to be complete from the date of first issue up to and through the year 1890 for each of the periodicals mentioned.

The Index admirably supplements the author's "Notes on the Literature of Explosives," which have been published from time to time in these pages, and is an invaluable reference list for military men and students of explosives in general. H. S. K.

ELECTRO-CHEMICAL EFFECTS DUE TO MAGNETIZATION. A dissertation presented to the Board of University Studies of the Johns Hopkins University for the degree of Doctor of Philosophy, by George Owen Squier, Lieutenant of Artillery, U. S. A.

This investigation was made under the supervision of Professor Rowland, who, after Professor Remsen's discovery in 1881 of the remarkable influence of magnetism on the deposition of copper from one of its solutions on an iron plate, experimented with Dr. Bell upon the "protective action" of points and ends of magnetic electrodes, and gave the mathematical theory of this action.

The principal results of Lieut. Squier's investigation are summarized as follows:

Whenever iron is exposed to chemical action in a magnetic field, there are two directly opposite influences exerted.

(*a*) The direct influence of the magnetized condition of the metal, causing the more strongly magnetized parts to be protected from chemical action.

(*b*) The indirect influence of the magnet caused by the concentration of the products of the reaction about the more strongly magnetized parts of the iron.

This tends to produce a higher potential at the more strongly magnetized parts and finally establishes permanent electric currents which go in the liquid from the more strongly magnetized to the neutral parts of the iron.

N. M. T.

Alternating Currents of Electricity; Their Generation, Measurement, Distribution and Application. By Gisbert Kapp, C. E. With an introduction by Wm. Stanley, Jr. 1893. The W. J. Johnston Co., Ltd., 41 Park Row, New York City. Price, $1.00.

This little book gives an easy and clear description of the graphical methods of the representation of alternating currents and, in the appendices, some mathematical deductions.

As stated by Mr. Stanley in his introduction to the book, it treats in a simple and yet effective manner of periodic currents in general, of the phase relations of impressed and induced electromotive forces possible in simple circuits, of alternating machines, of transformers, of the parallel coupling of alternators, of alternating current motors, of self-starting motors, and finally of multiphase currents.

The reader closes the book with surprise that so much has been so clearly presented in 150 pages, and with the wish that the author would extend and enlarge his treatment of this important subject. N. M. T.

BIBLIOGRAPHIC NOTES.

AMERICAN.

CASSIER'S MAGAZINE.

VOLUME III., No. 17, MARCH, 1893. Electricity and Our Coast Defenses. Modern Gas and Oil Engines. The Life and Inventions of Edison (continued). Practical Notes on the Steam Jacket. W. F. W.

IRON AGE.

VOLUME LI., No. 10, MARCH 9, 1893. Hydraulic Power Plant of U. S. Coast Defense Vessel Monterey. The New Shipping Bounty Laws of France.

MARCH 16. Hydraulic Machinery and Heavy Guns.

The effect of cold weather on the machinery for handling very heavy guns illustrated by the disabling of the Benbow.

Screw Propeller; Easy Method of Measuring the Pitch. The Cunard Steamship Campania. Machinists in the Navy (editorial).

MARCH 23. British War-Ship Construction.

Work done under the Naval Defense Act of 1889.

Trial of Dynamite Gunboat Vesuvius.

MARCH 30. Trial of Dynamite Gunboat Vesuvius (continued).

The Rapieff fuse and its trial.

The Torpedo-Boat Destroyer. The Development of the Injector.

An account of Giffard's invention and its later development.

Notes on British Armor and Ordnance.

APRIL 6. The Merriam Percussion Fuse.

Detailed account with illustrations.

APRIL 13. One Hundred and Thirty Ton Shears at the Maryland Steel Company's Works. The Davis-Farrar Triple-Expansion Engine.

APRIL 20. Merchant Cruisers and Government Subsidies. The Lee Piston Head. The Manufacture of Rifles.

Abstract of paper by the Superintendent of the Enfield Factory.

April 27. Bilge Strainers and Grease Extractors for Sea-Going Ships.

May 4. The New Western Electric Generator and Motor. The British Admiralty List of Reserved Merchant Cruisers.

May 18. The Allis Quadruple-Expansion Engine at the World's Fair. Smokeless Powder. A New Explosive (Maximite). A New Process of Tempering Steel. The Naval Review Fleets.

May 25. The Gatling-West Rifle. An Important Consideration in the Design of Boilers with Curved Back Heads.

June 1. Spring-Return 12-Inch Mortar Carriage.

A combination of a Russian and English design.

The Dow Compound Steam Turbine. C. M. K.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

Volume V., No. 1, February, 1893. Method of Running the Lines for the Shafting and Boring out the Stern Tubes and Brackets of the U. S. S. Cincinnati. Alignment of Shafting and Boring out Stern Tubes at the Union Iron Works. Steel Castings. Economical Speed and Coal Endurance of War Vessels. Contract Trial of the U. S. S. Monterey. High Smoke Pipes.

Memorandum stating the advantages gained by making the smoke pipes of Armored Cruiser No. 3 100 feet high instead of 60 feet.

Ships (U. S.). Particulars of Bids for the Construction of Armored Cruiser No. 3 (Brooklyn) and Sea-Going Battleship No. 1 (Iowa). Launch of the Katahdin (Harbor Defense Ram) at Bath. Successful Trial of the Bancroft and Speed Curves (mean speed for four hours, 14.37 Knots).

May. Experimental Comparison of a Single-Cylinder Engine with a Triple-Expansion Engine. Circulating Pumps. Experiments on the Arrangement of the Surface of a Screw Propeller. Marine Boilers. Supports for Boring Bars for Stern Tubes and Struts. The Worthington Marine Feed-Water Heater. Steam Pipes. The Contract Trial of the U. S. S. Bancroft. The Cunard Steamer Campania. Marine Boiler Furnaces. The Transmission of Heat Through Tube Plates. Effect of Auxiliaries on Economical Speed. Notes: Ships; Merchant Steamers. W. F. W.

JOURNAL OF THE FRANKLIN INSTITUTE.

Volume CXXXV., No. 807, March, 1893. Duty Trials of a Pumping Engine. A New Process for the Manufacture of Manganese on the Commercial Scale. Manganese Steel.

Mr. Howe concludes his article on manganese steel and its treatment. He suggests a possible use for it in armor, and from tests of a 2-inch

plate finds that its resistance is 48 per cent. greater than carbon steel. Its enormous and very constant electric resistance suggests important applications in electrical engineering.

Resistance to Ship's Motion.

APRIL. The Modern Travelling Crane.

Description of the 100-ton high-speed electric crane in the new erecting shops of the Baldwin Locomotive Works. Its span is 74 feet 8 inches; length of run-way, 336 feet; speeds (under absolute control) as follows: bridge travel, 100 and 200 feet per minute; trolley travel, crosswise, 50 and 100 feet per minute; hoisting and lowering, 5, 10, 20 and 50 feet per minute.

Resistance to Ship's Motion (continued).

MAY. Duty Trials of a Pumping Engine. Test of a One Hundred Horse-Power Gas Engine Using Producer Gas. Resistance to Ship's Motion (concluded).

JUNE. The Scientific Expert in Forensic Procedure. Rope-Power Transmission. A New Method of Reducing Metallic Oxides. H. S. K.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

MAY, 1893. The Evolution of Modern Drill Books (continued). Military Misconceptions and Absurdities. The Post Mess. The Flag of Truce.

A short article on the rules of intercommunication between belligerents under the flag of truce, and quotation of precedents.

Apprentice Schools for the Army. Military Uses of Photography. Target Practice. The Evolution of Tactics (trans.). H. S. K.

JOURNAL OF THE UNITED STATES ARTILLERY.

VOLUME II., No. 2, APRIL, 1893. Theoretical Discussion of the Brown Segmental System of Wire Gun Construction.

Lieut. Whistler, 5th Artillery, gives a thorough discussion of the system under the two heads of *General Discussion* and *Mathematical Discussion*. The general reader will be satisfied with the first part, which is complete in itself, except in so far as mathematical proof is needed for certain claims set forth.

The Artillery-Fire Game (trans.). Artillery Note; Answer to a Pamphlet issued by Armstrong & Co. in November, 1892, on R.-F. Guns (trans. from the French).

This paper is written in the interest of the Canet gun system, and is valuable in connection with the special number (Vol. I., No. 5, J. U. S. A.), which dealt very fully with the matter of English, French and German R.-F. guns. H. S. K.

JOURNAL OF THE U. S. CAVALRY ASSOCIATION.

VOLUME VI., No. 20, MARCH, 1893. Smokeless Powder in its Relation to Cavalry Efficiency. Some English Views of the

Mounted Action of the American Cavalry. The New Revolver. Professional Notes: Revolver Practice; Correct and Quick Pointing. H. S. K.

SCHOOL OF MINES QUARTERLY.

JANUARY, 1893. Comparison of Cost of Electric Lighting of Columbia College by Separate Plant and by Contract with Companies.

The article shows that the cost of lighting by separate plant is *one-fifth* the cost of the same light furnished by contract.

W. F. W.

THE STEVENS INDICATOR.

VOLUME X., No. 1, JANUARY, 1893. The Whitehead Torpedo.

A brief general description of the Whitehead automobile.

A New Recording Pressure Gauge for Extremely Low Ranges of Pressure. Cost of Castings. H. S. K.

FOREIGN.

ANNALEN DER HYDOGRAPHIE UND MARITIMEN METEOROLOGIE.

XXI. ANNUAL SERIES, 1893, VOLUME II. Drift Ice in Southern Latitudes. On Light Houses and Light Beacons (with Table). Sailing Route from Newcastle, N. S. W., to San Diego, Cal. A Rich Whale-Catch in the Arctic Ocean. Whaling in the Pacific Ocean and Bering Sea during the Decade 1860–1870. Observations on the Approach to Chemulpo, Corea. The Harbors of Casablanca and Magador, Morocco. A Voyage from Teneriffe to Bahia. Minor Notices: The Antarctic Whaling Fleet; Time Ball at Rio Janeiro; Meteorological Publications; New Regulations for Navigation on the Rivers and Streams of the Netherlands; On the Depth of Water in the Woosung River; Magnetic Observations on the East Coast of Siberia.

Meteorological Journals received at the German Obvervatory during the Month of January, 1893.

The Weather on the German Coast in January, 1893 (with Tables).

VOLUME III. Remarkable Tropical Revolving Storms in the Southern Indian Ocean. New Sea-Canals. Hydrographic Work in the Vicinity of the Eastern Entrance to Magellan Straits. Criticism of the Essay, "The Principal Atmospheric Currents." Voyage from Singapore to Colombo. Voyage from Hong Kong to Amoy, thence to Shanghai. Grenada. The State of the Water-Tides, and Pilotage in the Woosung River. Notes on San Diego, Cal. Voyage from Cardiff, England, to Port Pirie, S. Australia, thence to Newcastle, N. S.W. Climate of Madras. Minor Notices: Water Spouts in the North Atlantic.

Meteorological Journals received at the German Observatory in February, 1893.

The Weather on the German Coast for February, 1893 (with Tables).

VOLUME IV. The Harbor of Kunachee. The Action of Oil and Soapy Substances on Water in Calming the Waves. Extracts from the Cruising Report of Dr. Plehn of a Voyage to East Asia on the Steamer Priok. Drift Ice in Southern Latitudes (continuation). Rules Governing the Spelling of Geographical Names in Germany. Modern Meteorology.

Minor Notices: System of Observation-Terms Adopted in Germany; First Award of the Buys Ballot Medal; Shoals in Monte Christo Bay, San Domingo; Meteorological Observations on the Hawaiian Islands.

Meteorological Journals received at the German Observatory, March, 1893.

The Weather on the German Coast in March, 1893 (with Tables).

H. O.

BOLETIN DEL CENTRO NAVAL.

VOLUME X., DECEMBER, 1892. Modern Constructions; Plan of a Rapid Cruiser (continued). Tables for Calculating the Latitude by Means of Circumeridian Altitudes. The Naval School; Report of the Board of Examiners.

JANUARY and FEBRUARY, 1893. The Naval School. Reckoning Latitude at Sea. Modern Constructions; Project of a Rapid Cruiser (continued). Saving of Vessels in General; Means Applied in Rescuing the Howe. Compendium of Instructions for Gunnery Ships and Torpedo Stations in the Italian Navy. J. L.

DEUTSCHE HEERES-ZEITUNG.

FEBRUARY 18. Rapid-Firing Guns.

A brief review of their development in recent years, their effect on naval construction and tactics, and their adoption in the German navy.

Preserved Food; Its Use and Value in War.

FEBRUARY 22. The Organization of the Engineer Corps of the Italian Army. Officers' Pensions in the Different European States. Preserved Food; Its Use and Value in War (conclusion).

FEBRUARY 25. French Auxiliary Cruisers.

The requirements of the French Government and the preparations made to convert merchant steamers into auxiliary men-of-war, with a brief account of the recent mobilization of the steamer La Normandie.

MARCH 4. The German Plan of Naval Reconstruction.

A criticism of the plan adopted in 1888.

The French Manœuvres of 1893.

MARCH 11. Russian Black Sea Fleet.

APRIL 8. The United States Navy.

A brief description of the vessels lately built for the U. S. navy.

APRIL 12. The Reconstruction of the German Navy.

A brief review of changes in the vessels and armaments.

APRIL 19. The Ram in the United States Navy.

A criticism of the use of this type of vessel, and a description of the Ammen and Folger rams.

The Trials of the 6-cm. Krupp Rapid-Firing Field Guns of 30–38 Calibers, which Took Place near Meppin, Oldebrock and Schwingen, from 1889–1892.

APRIL 22. The Trials of the 6-cm. Krupp Rapid-Firing Field Guns, etc. (continuation).

APRIL 26. The Trials of the 6-cm. Krupp Rapid-Firing Field Guns, etc. (continuation).

The Fleets of the Naval Powers in 1853–54.

APRIL 29. The Trials of the 6-cm. Krupp Rapid-Firing Field Guns, etc. (conclusion). H. O.

THE ENGINEER.

MARCH 3, 1893. Bridging the Bosphorus.

Mr. James Garvie proposes bridging the Bosphorus, in connection with a system of projected railways centering in Constantinople. The width of the Bosphorus where the proposed bridge is to be placed is about 2200 yards, and the land is high on each side, so that a height of 220 feet above low water level could easily be provided.

History of the Cunard Steamship Company. Second Class Cruisers Sappho and Scylla. The Entrance to Colombo Harbor. U. S. Battleship Iowa. Machinery Trials of H. M. Torpedo Gunboat Circe.

MARCH 10. The Launching of the Campania and Lucania. Southampton and the American Line of U. S. Mail Steamers. History of the Cunard Steamship Company (concluded).

MARCH 17. U. S. Battleship Indiana. Mechanical Flight (Maxim). The Efficiency of Steam Engines.

MARCH 24. The Institution of Naval Architects. Mudd's Arrangement of Condenser Tubes. The Italian Cruiser Marco Polo. The Bearing of Recent Plate Trials on Future Warfare. The Russian Official Report on the Ochta Competition. Root's Oil Engine.

MARCH 31. Weir's Feed-Water Heater. The Flensburg Off-Shore Floating Dock. Harbors and Waterways.

APRIL 7. American Nickel Harveyed Plate Trial. Light Marine Boilers. Calorimetric Determination of Coal.

Description of the Mahler apparatus and method.

APRIL 14. Roller and Ball Bearings. The United States Navy. The Fastest Paddle Steamer in the World (Leopold II.). The Draughtometer.

An instrument designed to show the draught from inboard, and even on deck, by means of an ingenious electrical attachment.

Sutherland's Electric Deck Planer. Ross' Steam and Pneumatic Caulking Tool. Umpires' Report on the Naval Manœuvres, 1892. The Daimol Petrol Motor.

APRIL 21. The U. S. Dynamite Cruiser Vesuvius. The Propulsion of Ships. Kirkaldy's Compactum Evaporator Feed-Water Heater.

APRIL 28. United States Atlantic Liners. Compound Marine Engines. Priestman's Petroleum Engine.

MAY 5. Shipbuilding in France. Trial of a Triple-Expansion Condensing Engine. Copper for Fireboxes. Trials of H. M. SS. Ramillies and Alarm. The Rocket Petroleum Engine.

MAY 12. Harbors and Waterways. Ignition Tubes for Gas Engines. The Analysis of Engine Tests. A New Electricity Meter. Trial of H. M. S. Empress of India.

MAY 19. The Report of the Navy Committee on Boilers. Human's Logarithmic Co-ordinate Sheets. Lessons Learnt at Sea by a Marine Engineer. Italian Naval Progress. Ship Canals.

MAY 26. H. M. S. Speedy. Dassen Island Lighthouse. Bronze Screw Propellers. Mudd's Tail Shaft Preserver. The Ejector Condenser. Trial of H. M. S. Crescent. H. S. K.

ENGINEERING.

VOLUME IV., NO. 1418, MARCH 3, 1893. The Development and Transmission of Power from Central Stations.

MARCH 10. The Engines of H. M. SS. Circe, Alarm and Lida. The Desroziers Continuous Current Dynamo. H. M. S. Blenheim.

Mr. W. H. White discusses the trials of the Blenheim and claims 22½ knots speed for a forced draught four hours' continuous sea speed.

The American Line of Steamers. Mechanical Flight. Alloys. Notes: New Docks at Portsmouth; Naval Engineers; The United States Ram Katahdin; The Trials of the Repulse; High-pressure Hydraulic Presses in Iron Work.

MARCH 17. Alloys. Trials of H. M. S. Vulcan. Experimental Apparatus at Haslar.

Description of the experimental apparatus and shaping machine for ship models at the Admiralty Experiment Works, Haslar.

MARCH 24. The Austrian Torpedo Cruiser Satellit.

On her trial run made 22.5 knots, 1.5 knots more than contract requirements.

Engineering Theory and Practice. Alloys. The Institution of Naval Architects.

Notice of the annual meeting, the address of the President, and of papers by Rear-Admiral Samuel Long and Lord Brassey on The Position of Cruisers in Warfare, and Merchant Cruisers Considered with Reference to the Policy of Maintaining a Reserve of Vessels by Annual Subventions to Shipowners, respectively.

Efficiency of Dynamo-Electric Machines. Some Mechanical and Electrical Analogies.

MARCH 31. The Institution of Naval Architects (continued).

Notice of papers on The Strength of Bulkheads, Measurements of Wake Currents, Propulsion of Ships, The Transmission of Heat through Tube-plates (published in full on another page), Alterations in Boilers under Pressure, Vibrations of Steamers, Repairs of Ships, and Curves of Stability.

The American Inventor. Quick-Firing Guns in the Field. Alloys. American Institute of Mining Engineers.

Notice of the Greene-Wahl process for manufacturing manganese and its alloys free from carbon.

APRIL 7. The Institution of Naval Architects. European Canals. The Use of Superheated Steam in Steam Engines. Harmonic Valve Diagram. The Measurement of Wake Currents. The Strength of Bulkheads.

APRIL 14. The Murren Wire-Rope and Electric Mountain Railway. The Nicaragua Canal (continued). Boat Railway at Meaux, France. Merchant Cruisers. Merchant Cruisers Considered with Reference to the Policy of Maintaining a Reserve of Vessels by Annual Subventions. The Vibrations of Steamers.

APRIL 21. The Cunard Royal Mail Twin-Screw Steamers Campania and Lucania. The World's Columbian Exposition, 1893. Shipbuilding on the Thames. Speed Trials of the Campania. The Condition of the Shipbuilding Trade.

This very handsome number is of especial interest from its very full description of the two latest additions to the Cunard fleet, and also of the Columbian Exposition. Both articles are very complete and are admirably illustrated, occupying together about 130 pages. The former deals with the design, the hulls, the launch, construction of engines and boilers, electric lighting, navigating appliances, passenger accommodations, ventilation, commissariat, refrigerating plants, and cargo appliances; the latter opens with a brief notice of the four trunk lines connecting New York and Chicago, and, after a short historical sketch of the Exposition and of the city in which it is to be held, goes on to describe in detail the more important buildings, closing with a description of the means of communication. A reprint has since been published, price 6s.

APRIL 28. The Nicaragua Canal. Institution of Mechanical Engineers.

Notice of meeting, and discussion of the two papers read, viz., Copper Plates for Locomotive Fireboxes, and Alloys. The former is published in full, and the latter (which is the second report of the Alloys Research Committee) is begun in another part of this issue.

United States Cruiser Olympia. Trial of H. M. S. Ramillies.

MAY 5. English and American Locomotives. Compound Engines of the Japanese Cruiser Unebi. The Strength of Basic Bessemer Steel Joists. Phillips' Flying Machine. Iron and Steel in Sweden. Trial of H. M. S. Ramillies. Alloys (continued).

MAY 12. The Report of the Admiralty Boiler Committee. Alloys (concluded).

MAY 19. Boilers in the Navy. H. M. S. Speedy. Power Trials of H. M. S. Ramillies. On Some Experiments with the Engines of the S. S. Iveagh.

Two four hour runs were made under different conditions. In the first, the engines were run as compound, the intermediate cylinder being disconnected; in the second, all three were in action. The boiler efficiency was the same in both. While the arrangement of cylinders, cut-offs, etc., in the compound arrangement was not the most favorable, the results show that with 2 lbs. more boiler pressure on the second trial, three additional revolutions, 0.24 knot more speed, and 80 additional H. P. were attained, the consumption of coal falling from 134 to 94 lbs. per nautical mile.

The Cyclogram. Fixing Boiler Tubes. Machinery Trials of H. M. S. Empress of India.

MAY 26. A New Type of Cargo Steamer. Naval Engine-Room Efficiency. Explosives. The Iron and Steel Institute.

Report of the Council and address of the President.

Alterations of Form of Boilers under Steam. The Manufacture of Small-Arms. H. S. K.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOLUME XXXVII., No. 180, FEBRUARY, 1893. The System of Mounting and Placing Guns on board Ships of the Royal Navy. By G. O. Arnold-Foster, M. P.

Mr. Arnold-Foster criticises the placing rather than the mounting of guns as generally found in British ships. His two special points are the placing of guns in pairs in turrets or barbettes, and the small average height of heavy guns above the water-line, both of which he considers very faulty, instancing French practice in support of his views. Very naturally his views are not generally endorsed in the discussion.

France and Her Marine (Mercantile and War) (trans.). Recent Progress in Marine Machinery (trans.). Moltke's Tactical Exercises, 1858–82.

MARCH, 1893. Electric Balloon Signaling. The Different Systems of Signaling in the Field. The Buonaccorsi Automobile Torpedo (trans.).

The Magazine Rifle of 6.5 mm. (0.2569 in.) Calibre, Mannlicher System (trans.).

APRIL, 1893. The Military Organization Best Adapted for Imperial Needs. Engine-Room Telegraph (trans.). England's Position in the Mediterranean (trans.). French Small-arm Smokeless Powder.

MAY. The Military Organization Best Adapted to Imperial Needs. Modern Warfare as Affecting the Mercantile Marine of Great Britain.

Lieut. Crutchley, R. N. R., advocates the partial arming of merchantmen for the purpose of self-protection.

Our Swordsmanship.

This lecture by Captain Hutton has attracted considerable attention in England. In it he criticises with considerable particularity the methods in use in the English army, and lays to their charge the lack of interest in the subject among officers which he so greatly deplores.

The Contemporary Navies of the European Powers. The Battleships of England. The Russian Official Report on the Ochta Competition. Experimental Firing with the 6-cm. Q.-F. Field Guns at the Krupp Works in Germany. Naval and Military Notes.

H. S. K.

MILITÄR-WOCHENBLATT.

FEBRUARY 18. Army Reorganization and Military Service in Switzerland. The New Recruiting Law of Italy. Historical Sketch of the Russian Military Institutions.

FEBRUARY 22. Army Reorganization and Military Service in Switzerland (conclusion). The Condition and Strength of the Austro-Hungarian Army.

FEBRUARY 25. The Present Organization and Strength of the French Infantry. The Preparation of Provisions in War. Cooking Schools in the English Army.

MARCH 18. The Condition of the Russian Army for War. Military Schools of Switzerland in 1893.

MARCH 22. The Condition of the Russian Army for War (conclusion).

MARCH 27. The Law in Regard to the Superior Council of War of France.

MARCH 29. The Bulgarian Army and its Budget for 1893.

APRIL 1. The Stranding of H. M. S. Howe.

A brief review of the circumstances attending the stranding of the Howe at the entrance to the harbor of Ferrol, and of the result of the trial of her commander and navigating officer.

APRIL 5. The Stranding of H. M. S. Howe (conclusion).

A review and criticism of the result of the trial of Vice-Admiral Fairfax, the Commander-in-Chief of the Channel Squadron.

Dahomey.

APRIL 8. The Military Service of Germany in the War with France, 1870–71.

APRIL 12. Same (continuation).

APRIL 15. Same (conclusion).

APRIL 19. Military Statistics of the Franco-German War of 1870–71. A Naval War of the Future.

A criticism of Mr. Laird Clowes' recent publication "The Mary Rose."

APRIL 20. The Reorganization of the Military School of Portugal.

APRIL 29. Fire-Practice of Infantry to Solve Certain Tactical Questions. A New French Cruiser.

A description of the Descartes.

MAY 17. Casualties in the Principal Battles of the Last Hundred Years.

A refutation of the article under the above title, which appeared in the Prussian Annual of April last.

Wire-Wound Guns.

A review of the different guns constructed on this system, and a description of the latest Brown segmental wire-wound gun.

MAY 20. Casualties in the Principal Battles of the Last Hundred Years, etc. (conclusion).

SUPPLEMENT TO MILITÄR-WOCHENBLATT.

VOLUME 344. The Impressions of a Military Tourist in the Caucasus and Southern Russia, by Captain V. Drygalski of the German Cavalry. H. O.

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS.

VOLUME CXI. Halifax Graving Dock. Biloela Graving Dock, Cockatoo Island, Sydney Harbor, N. S. W. Alexandra Graving Dock, Belfast. Construction of a Concrete Graving Dock at Newport, Mon.

These papers give more or less full descriptions of the several docks mentioned, and a discussion on the general subject follows.

The Manufacture of Small-Arms.

Mr. Rigby's paper is a full description of the methods of small-arm manufacture at the Royal Small-Arms Factory, Enfield. It is very fully discussed, and the article and discussion are very interesting reading.

Relative Power of Lighthouse Lenses. The Port of Genoa. Method of Coppering Ships by Deposition. The National Small-Arms Factory at Liége. H. S. K.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XXI., Nos. 1 and 2. The Steam Commerce of Austro-Hungary. The Fundamental Laws of Astronomy from a New Point of View (a study). The Latest Method of Determining the Deviation of the Compass, and of the Compensation of the Compass by Bearings of an Indeterminate Object. Naval Manœuvres of 1892. A Comparison Table of the Most Reliable Data of the 10-cm., 12-cm. and 15-cm. Rapid-Firing Guns of the Following Systems: Armstrong, Canet, Hotchkiss, Krupp, Maxim-Nordenfeldt and Schneider. Naval Budget of Russia for 1893. The Stranding of the Howe off Ferrol. The New Compass-Card of Dr. P. J. Kaiser of Leyden. A New Rocket Apparatus for Life-Saving. The Acceptance Trials of the Chilian Armorclad, Captain Pratt. Smokeless Coal Consumption. The Use of Naphtha on Warships and Torpedo-Boats.

No. 3. The Stability of the Axis of Rotation, Especially as Regards the Howell Torpedo (a study). The Annual Report of the Engineer-in-Chief of the United States Navy. The Naval Budget of England for 1893–94. Trial Runs of the Danish Cruiser Geiser. The Steam Tests of the Towne Boiler, with Table of Results. H. O.

LE MONITEUR DE LA FLOTTE.

No. 19, MAY 13. New Navy Constructions.

MAY 20. Wireless Electric Communications Between Ships at Sea.

"In a late communication, read before the Royal Association of Edinburgh, upon long distance induction through air and water without the use of parallel wires, Mr. Stevenson proposes a method that may prove useful in establishing electric communications between ships at sea."

J. L.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

MARCH, 1893. Okehampton Experiences, 1892 (Artillery Practice).

"*Cordite.* The great difficulty that has attended the introduction of cordite is that of securing a suitable vent and friction tube. The rush of gas, if unchecked, is so violent that the ordinary steel vent gutters away and is unserviceable after a few rounds (varying from 10 to 30). Apparently, the only way out of the difficulty lies in some form of vent-sealing tube. More than a dozen different forms have been tried, but as yet without very much success, and it has been found difficult, so far, to design anything that will be both effective as a vent-sealer, and at the same time not so clumsy as to effect the service of the gun."

Recent Development of Armor and its Attack by Ordnance (concluded).

Notes the Elswick experimental gun of 100 calibres which gave a 100-lb. projectile a velocity of 3231 f.-s., and a 70-lb. projectile 3711 f.-s.; the Ochta trials of armor in November and December, 1892; and discusses briefly the attack of ships.

APRIL. The Strategical Geography of Europe. Notes on Optical Instruments. The Value of a High Site for Coast Artillery.

MAY. The Effect of the Rotation of the Earth on the Motion of Projectiles.

A short mathematical paper of theoretical interest only; the assumption is made that gravity is constant in magnitude and direction throughout the flight of the projectile.

Modern Gunpowder and Cordite.

An interesting lecture.

The Military and Naval Power of the United States (trans.).

H. S. K.

REVISTA TECNOLÓGICO INDUSTRIAL.

NUM. 1., AÑO 16, JANUARY, 1893. Resistance of Materials; a Study of the Tests of Iron and Steel.

Lecture delivered by M. E. Cornut in the Congress of Applied Mechanics (continued).

Descriptive and Rational Chemistry.

Address read at the opening of the Academic Course, 1892–93, in the University of Madrid.

J. L.

REVUE DU CERCLE MILITAIRE.

NO. 20, MAY 14. A Manœuvring Column in the South-Oran (Africa). The Infantry Armament and Prof. Hebler's Formula (ended). The Servian Army (ended).

MAY 21. The Naval Review and Parade in New York. A Military Co-operative Association in Russia. J. L.

REVUE MARITIME ET COLONIALE.

VOLUME CXVI., MARCH, 1893. Cruisers; Their Rôle; The Conditions they Must Fulfill (by Vice-Admiral de Cuverville). Historical Notice of the Trial Board of Artillery at the Gâvre Proving Grounds (continued). A Study of the Mechanical Theory of Heat (continued). The Actual State of the National (French) Navy. Circulation of Wind and Rain in the Atmosphere. Utilization of Screw Propellers. In the Land of the Kanacks; New Caledonia and its Inhabitants in 1890. The United States Navy (trans.).

MAY. A Study of the Theory of Naval Warfare. Cruisers.

"The writer, E. Guiffort, an Ensign in the French navy, who lost his life in the wreck of the Labourdonnais in a cyclone at Madagascar, in February last, is convinced that the modern fast cruisers will play a very important strategic as well as tactic part in the next wars. The present study aims to show the nature of the duties assigned to them and hints at the changes that will take place in actual combat as well as in subsequent manœuvres."

Simultaneousness of Gun Loading and Firing (with a full description of the apparatus). Mechanical Solutions of Problems in Navigation. Circulations of Wind and Rain through the Atmosphere. Two New Theorems in Physical Astronomy in Regard to the Unequal Distribution of Heat upon the Surface of the Northern and Southern Hemisphere of the Terrestrial Globe. J. L.

REVISTA DI ARTIGLIERIA E GENIO.

VOLUME I., FEBRUARY, 1893. Advance in the Art of Modern Cartography in Europe. Artillery Drill in the German Army. Considerations on the Fire Probability in Ship and Coast Batteries (continued).

MARCH. Advance in the Art of Modern Cartography in Europe (ended). Considerations on the Fire Probability in Ship and Coast Batteries (six plates). The Method of Indirect Firing in Field Artillery.

VOLUME II., APRIL. A Brief Consideration of the Field Artillery Regulations. Temporary Fortifications and the New Means of Attack. Fuses and Detonators in Use in German Artillery (1 plate). Instructions in Carrying Out Fire Practice. J. L.

THE STEAMSHIP.

VOLUME IV., No. 46, APRIL, 1893. Delta White Anti-Friction Metal Tests.

Table of results of tests made by Professor W. C. Unwin.

Cumming's Shaft Leveller.

An instrument specially designed for testing the alignment of propeller shafts on shipboard; it is simple and effective.

W. F. W.

UNITED SERVICE GAZETTE.

FEBRUARY 25, 1893. Egypt and the Red Sea.

MARCH 4. The Admiralty and the Stranding of the Howe. The Navy Estimates. Strategy in the American Civil War.

MARCH 18. The State of the Navy.

MARCH 25. M. Weyl on the Recent Admiralty Minute. The Naval Manœuvres, 1891, I. The Manning of the Navy.

April 1. Field Guns. Military Law. Engine-Room Artificers. The Naval Manœuvres, 1892, II. Our Need of Cruisers. Smokeless Powder in Warfare.

April 8. Naval Supremacy.

April 15. The Value of the Torpedo-Boat. Imperial Defense.

April 22. Our Position in the Mediterranean. The Invasion of England.

April 29. The Future of the Torpedo.

May 6. Our Relative Strength at Sea. Continuity of the Effective Service of Warships. Photographing Flying Bullets.

May 13. The Personnel of the Navy.

May 20. Our Naval Strength.

May 27. Our Naval Requirements. H. S. K.

LE YACHT.

No. 792, May 13. The Naval Review and Boat Races at New York.

May 20 and 27. The Contemplated New Armorclads (E. Weyl). J. L.

EXCHANGES, BOOKS AND PERIODICALS RECEIVED.

Alternating Currents of Electricity.
American Chemical Journal.
American Engineer and Railroad Journal.
Annalen der Hydrographie und Maritimen Meteorologie.
Annual Report of the Chief of Engineers, U. S. Army, 1892, Parts 1, 2, 3 and 4, and Atlas.
Army and Navy Register.
Boletín del Centro Naval.
Bulletin of the American Geographical Society.
Bulletin of the American Iron and Steel Association.
Bulletin of the Geographical Society of California.
Cassier's Magazine.
Civilization Among the Sioux Indians.
Colliery Engineer.
Deutsche Heeres-Zeitung.
Electrical Review.
Electricity and Magnetism of Advance Primers of Electricity.
Electro-Chemical Effects due to Magnetization.
Engineer, New York.
Engineer, London.
Engineering, London.
Engineering-Mechanics.

Engineering News and American Railroad Journal.
Index to the Literature of Explosives, Part II.
Iron Age.
Journal and Proceedings of the United Service Institution of New South Wales.
Journal of the American Society of Naval Engineers.
Journal of the Association of Engineering Societies.
Journal of the Franklin Institute.
Journal of the Military Service Institution.
Journal of the Royal United Service Institution.
Journal of the United States Artillery.
Journal of the United States Cavalry Association.
Lend-a-Hand.
Marine Review.
Militär-Wochenblatt.
Minutes and Proceedings of the Institution of Civil Engineers.
Mittheilungen aus dem Gebiete des Seewesens.
Mémoires et Compte Rendu Des Travaux De La Société Des Ingénieurs Civils.
Le Moniteur de la Flotte.
Norsk Tidsskrift for Sovaesen.
Pacific Militant, Vol. i., Nos. 1 and 5.
Proceedings of the American Academy of Arts and Science.
Proceedings of the American Philosophical Society.
Proceedings of the Institution of Mechanical Engineers.
Proceedings of the Royal Artillery Institution.
Railroad Gazette.
Revista Maritima Brazileira.
Revista Tecnológico Industrial.
Revue du Cercle Militaire.
Revue Maritime et Coloniale.
Rivista Marittima, Rome.
School of Mines Quarterly.
Statistics of the American and Foreign Iron Trades for 1892; Annual Statistical Report of the American Iron and Steel Association.
Steamship.
Technology Quarterly and the Proceedings of the Society of Arts.
Teknisk Tidskrift.
Tidskrift i Sjöväsendet.
Transactions of the American Society of Civil Engineers.
Transactions of the North of England Institute of Mining and Mechanical Engineers.
Transactions of the Technical Society of the Pacific Coast.
U. S. Geological Survey; Mineral Resources of the United States.

United Service Gazette.
United Service.
World's Fair Electrical Engineering.
Le Yacht.

REVIEWERS AND TRANSLATORS.

Lieut.-Comdr. J. P. Merrell.
Lieutenant Hugo Osterhaus.
P. A. Engineer W. F. Worthington.
Ensign C. M. Knepper.
Professor N. M. Terry.
Professor Jules Leroux.
Lieutenant H. S. Knapp.

NAMES OF MEMBERS WHO HAVE JOINED SINCE JULY, 1892.

Regular Members.

Benson, Wm. S., Lieutenant, U. S. Navy.
Berry, David M., Naval Cadet, U. S. Navy.
Bisset, Eugene L., Naval Cadet, U. Navy.
Brady, J. R., Naval Cadet, U. S. Navy.
Campbell, E. H., Naval Cadet, U. S. Navy.
Carver, Marvin, Naval Cadet, U. S. Navy.
Clark, F. H., Naval Cadet, U. S. Navy.
Cook, A. M., Naval Cadet, U. S. Navy.
Crosley, Walter S., Naval Cadet, U. S. Navy.
Doddridge, John S., Naval Cadet, U. S. Navy.
Douglas, R. T., Naval Cadet, U. S. Navy.
Elder, E. A., Naval Cadet, U. S. Navy.
Everhart, L. H., Ensign, U. S. Navy.
Fewel, C. C., Naval Cadet, U. S. Navy.
Fitch, Claude E., Naval Cadet, U. S. Navy.
Gise, Wm. K., Naval Cadet, U. S. Navy.
Gove, Chas. A., Lieutenant, U. S. Navy.
Hains, P. C., Naval Cadet, U. S. Navy.
Holsinger, Gerald L., Naval Cadet, U. S. Navy.
Jackson, Orton Porter, Naval Cadet, U. S. Navy.
Lang, C. J., Naval Cadet, U. S. Navy.
McCormick, C. M., Ensign, U. S. Navy.
McKethan, A. A., Naval Cadet, U. S. Navy.
Montgomery, W. S., Naval Cadet, U. S. Navy.
Morris, John R., Naval Cadet, U. S. Navy.
Olmsted, Percy N., Naval Cadet, U. S. Navy.
Parker, Thomas D., Naval Cadet, U. S. Navy.
Perry, Joseph A., Naval Cadet, U. S. Navy.
Peugnet, M. B., Naval Cadet, U. S. Navy.
Pollock, E. R., Naval Cadet, U. S. Navy.
Potter, Jas. Boyd, Naval Cadet, U. S. Navy.
Powell, Wm. G., Naval Cadet, U. S. Navy.
Powelson, W. Van Nest, Naval Cadet, U. S. Navy.
Pratt, Alfred A., Naval Cadet, U. S. Navy.
Procter, A. M., Naval Cadet, U. S. Navy.

Ritter, Henry S., Ensign, U. S. Navy.
Sticht, John Low, Naval Cadet, U. S. Navy.
Stitt, Thomas L., Naval Cadet, U. S. Navy.
Upham, F. Brooks, Naval Cadet, U. S. Navy.
Ward, Henry H., Naval Cadet, U. S. Navy.
Wells, Chester, Naval Cadet, U. S. Navy.
Wilson, Thomas S., Naval Cadet, U. S. Navy.

Associate Members.

Acland, F. E., Captain (Late of the Royal Artillery).
Blackwell, F. O., Lieutenant, Naval Brigade, Mass. V. M.
Bloodgood, W. D., Lieutenant, Naval Battalion, N. G. C.
Borden, Richard P., Ensign, Naval Brigade, Mass. V. M.
Cary, W. A., Lieutenant, Naval Brigade, Mass. V. M.
Cheneau, E., Franco-American Cellulose Co., Philadelphia, Pa.
Crocker, C. H., Lieutenant, Naval Battalion, N. G. C.
Denny, A. B., Ensign, Naval Brigade, Mass. V. M.
Dohrman, H. G., Steubenville, Ohio.
Durfee, Nathan, Lieutenant, Naval Brigade, Mass. V. M.
Garvie, James, M. E., Southgate Engineering Co., England.
Hadfield, R. A., Steel Manufacturer, Hadfield Steel Works, England.
Hayes, Hammond V., Lieutenant, Naval Brigade, Mass. V. M.
Heese, Albrecht, Lieutenant, Royal Prussian Artillery Guards, and Attaché to the Imperial German Legation.
Hervey, Homer W., Naval Brigade, Mass. V. M.
Hey, George W., Counsellor-at-Law, Syracuse, N. Y.
Houghton, Clement, Mass. V. M.
McClymont, E. E., Mechanical Engineer and Naval Architect.
Morgan, Daniel, Maysville, Ky.
Noble, R. H., Lieutenant, 1st Infantry, U. S. Army.
O'Neill, J. J., Naval Architect.
Sprague, Timothy W., Lieutenant, Naval Brigade, Mass. V. M.
Turner, Louis H., Lieutenant, Naval Battalion, N. G. C.
Tyler, Willard C., President and Manager of the Eastern Department of the Railway Review of Chicago.
Williams, Franklin D., Lieutenant and Adjutant, Naval Brigade, Mass. V. M.

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PROCEEDINGS

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THE PROCEEDINGS

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

RESULTS OF SOME SPECIAL RESEARCHES AT THE TORPEDO STATION.

COMPILED BY LIEUTENANT H. S. KNAPP, U. S. NAVY.

During several years past special researches have been carried on at the Torpedo Station at Newport in connection with questions that have arisen there and at the Navy Department. Through the courtesy of the Chief of Bureau of Ordnance, the Institute is allowed to publish in the PROCEEDINGS the results of some of these researches which have never before been made public.

The compilation here presented is far from being a complete record of the work done, for practically all of the reports contain quantities of data which it is impracticable to reproduce in these pages. But the attempt has been made, where it seemed worth while, to give some idea of the method of experimentation, and a summary of the results attained. The conclusions reached by the experimenters are generally given in their own language as taken from the official reports.

In what follows, the character of the research is indicated by the words italicized.

How little fulminate of mercury will detonate atmospherically dry gun-cotton?—As the result of a large number of carefully conducted experiments, the Committee on Explosives, to whom the research was entrusted, report as follows: "In conclusion we would say from inspection of our results, that it has been shown beyond question that atmospherically dried gun-cotton of our own manufacture may, when freely exposed to the air and untamped, be detonated with certainty by five (5) grains of fulminating mercury, and that it may be detonated, though not with certainty, with three (3) grains, and that consequently the coefficient of assurance for our service detonators, of 35 grains, is seven (7). Hence it is shown beyond doubt that with detonators manufactured as described in our report* of January 15, 1887, there is not the least danger of failure to be apprehended so far as the fulminate charge is concerned, and we regard the fact that the weight of fulminate adopted for the service gives so large a coefficient of assurance as, in so vital a matter, a very wise condition."

How little fulminate of mercury will detonate perfectly dry gun-cotton?—The gun-cotton experimented with was steam-dried to constant weight. The results obtained by the Committee, as given in their report, show "that perfectly dry gun-cotton may be detonated by 2.83 grains of fulminate of mercury; that in twenty-five experiments with amounts varying from 2.28 grains to 3.91 grains there were but seven failures; that with from 3.73 grains to 3.91 grains there were no failures; and that, in the case of all the failures recorded, it is noted that the gun-cotton was burned and not burst, as was the case with failures in the study of Topic 5 [the preceding]. This would seem to point either to a lack of sufficient confinement of the fulminate in the detonator or of imperfect contact of the detonator with the gun-cotton. Both of these conditions are noted in the record: the first resulting from the difficulty found in procuring suitable plugs; the second from insufficiently inserting the detonator in the detonator hole. We may conclude that, when the detonator is well made and placed in intimate contact with the gun-cotton, the latter will certainly be detonated by a charge of 2.83 grains of fulminate of mercury, and probably with less; and we would recommend that, when opportunity offers, this topic be again studied, and that still smaller charges be used."

*See p. 251.

Is the explosive force of gun-cotton greater when a greater quantity of fulminate is employed than when the minimum quantity is used?—The Committee on Explosives report as follows: "From experiments conducted at this station . . . . with varying amounts of fulminate of mercury, the Committee conclude that the explosive effect is not increased by the use of more fulminate than is necessary to produce detonation.

"As these experiments were made with gun-cotton with an extremely small percentage of moisture, the Committee do not recommend any decrease of the amount of fulminate of mercury in the service detonator."

To devise means for the rapid production of detonators of a definite and uniform quality.—The results obtained by the Committee on Explosives settled satisfactorily one point, viz.: that detonators of excellent quality can be so prepared as to be fit for use within a week from the time of filling. The method of preparing the fulminate of mercury is due to Professor C. E. Munroe, who was, at the time of the investigation, chemist at the Torpedo Station.

Up to July, 1886, there had been many failures in experiments with gun-cotton and other high explosives, which were believed to be due to a lack of uniformity in the detonators, metallic mercury being often found mingled with the fulminate. Moreover, it was considered necessary to allow three months' drying after filling the cases before bridging, priming and plugging the detonators.

Professor Munroe succeeded in producing fulminate that was shown under the microscope to be free from metallic mercury and other mercury salts, and to consist of *one kind* of crystals only. The method pursued was as follows: 10 grams of mercury were dissolved in the cold in 120 grams of nitric acid, specific gravity 1.45 +. When the solution was complete and the liquid cool, this solution was poured into a flask containing 110 grams of alcohol of 95 per cent. Action soon began without the mixture being previously heated, and was eventually quite active, but it was allowed to continue without molestation until it ceased naturally. The mass was then treated with water, and washed until no longer acid. Repeated trials with fulminate produced in this way proved it to detonate easily and violently.

To shorten the time necessary for drying the fulminate in the

detonator cases, alcohol was used instead of water as the moistening agent to prepare the fulminate for loading. Preliminary experiments were successfully made to show that fulminate moistened with alcohol is insensitive to blows, friction or shocks. Later on this point was further proved in a most satisfactory way by the failure of detonators to explode in instances where there had been insufficient drying, portions of the fulminate being found unexploded inside and outside of the cases, the priming having blown the cases open.

A quantity of fulminate which had been stored in water was placed in a dish, the water decanted, and the mass covered with 95 per cent. alcohol. It was washed in this alcohol three times by decantation, the alcohol being thoroughly stirred in each time. Detonators filled with this fulminate were tested unsuccessfully after drying for periods varying from two days to two weeks, when they were found to explode violently and completely.

Later on "another lot was made up by the same method, stronger alcohol being used, greater care being taken in mixing the alcohol and fulminate, and also the time of exposure to the action of alcohol was prolonged. This lot was dry enough to explode in a week."

Again "another experiment was made by placing the fulminate in a muslin filter. When the water had ceased to run through, absolute alcohol was poured upon the mass in excess and allowed to drain off three successive times." A case filled with this was detonated after drying only twenty hours.

The Committee made a large number of experiments with detonators of fulminate, made and filled as described above. In one instance, of fourteen filled on Dec. 21, ten detonated on the 23d, and one of the failures was found to be due to broken leading wires. This detonator was exploded on the 24th. Three lots of ten each were made on successive days for the sole purpose of seeing whether one week's drying would suffice. All were successfully detonated one week after filling. An incidental experiment, made to test the priming with cases filled with sand in place of fulminate, showed that, in seven trials, the plug was always blown out, and in several instances the case was shattered.

The Committee's report says: "In conclusion, we would state that our experiments have convinced us that the method of drying which we have employed will enable us to produce detonators which are reliable and fit for use within one week after the cases are filled ;

and we believe that, under thoroughly favorable conditions, the time necessary for the production of reliable detonators may be reduced considerably below a week."

To determine whether gun-cotton and other high explosives can be detonated by gunpowder when strongly confined.—The conclusions reached were "that the only cases of detonation which occurred were obtained by the use of the service detonator, and that there was no detonation, or even an approximation to it, when gunpowder igniters were used, notwithstanding that the explosives were confined in strongly resisting envelopes."

To determine the largest percentage of water gun-cotton may contain, and yet be detonated with certainty.—The Explosives Committee, in dealing with this question, considered it under four heads, viz.: 1, gun-cotton moistened with fresh water and fired by a detonator alone; 2, moistened with salt water and fired by a detonator alone; 3, moistened with fresh water and fired by the aid of a primer of dry gun-cotton; 4, moistened with salt water and fired by the aid of a dry primer.

Working under the first head, the gun-cotton was steam-dried to constant weight, and allowed to cool in a closed tank over night, when the dry weighings were made. To moisten the blocks, they were immersed in fresh water for a shorter or longer time and then exposed to the air until the standing moisture was absorbed; the wet weighings were made just before undertaking experiments.

Out of fifty trials, detonation uniformily occurred in eleven instances where the percentage of moisture varied from 6.61 to 13.04, and failed uniformly in five instances where the percentage was 18.18 and above up to 25.60. Between the intermediate limits there were eighteen failures and sixteen detonations, occurring in no regular way, the highest percentage of moisture where detonation resulted being 17.96. In addition, three blocks were taken directly from the press (in which condition the usual percentage of moisture varies from 14 to 16) and two were tried with one detonator and the third with two detonators in series. In neither case did detonation ensue.

Among the possible causes of the singular lack of uniformity in the results, the report mentions the "Vortex Theory" as enunciated by Threlfall, the failure of the detonators, unequal distribution of moisture, and lack of homogeneity in the gun-cotton discs.

The material used in the detonators was made in the manner prescribed in the report of the Committee, "To devise means for the rapid production of detonators of a definite and uniform quality," and its purity and dryness were beyond question. Some mechanical faults were discovered in the cases, however, and after their rectification somewhat better results were obtained. With increasing percentages of moisture anomalies again occurred, however, showing that the failures could not be accounted for by imperfect detonators alone.

The unequal distribution of moisture in the disc seems, perhaps, the most satisfactory explanation. That the distribution was not uniform was proved by examination of the fragments of recently moistened discs. Thus the apparent percentage of moisture of the whole block might be, and probably was, less, and perhaps much less, than was the case in the part immediately in contact with the detonator which had been directly exposed to the water in the detonator hole during immersion.

Under the second head, the experiments showed similar anomalous results, which may be explained in a similar way.

The conclusions of the Committee under these headings were as follows:

". . . . Our experiments show that a gun-cotton disc containing as much as 13 per cent. of fresh water, uniformly distributed in it, can be detonated with a service detonator, and that one containing 18 per cent. may be sometimes so detonated."

". . . . Our experiments show that a gun-cotton disc containing as much as 12.89 per cent. of salt water, uniformly distributed through it, can be detonated by a service detonator, and that one containing 15.22 per cent. may sometimes be so detonated."

Uninterrupted success attended the experiments conducted under heading 3. Sixteen discs, containing from 19.46 to 30.89 per cent. of moisture were fired without a failure. Then, as a final test, there were two successful experiments of the following nature: A disc which had been soaked for one and one-half hours was immersed in a can of water, and on it was placed a dry disc so coated as to be impermeable to water. As thus arranged, both discs were fired and the detonation was complete. The report says: "Hence we concluded that gun-cotton which is completely saturated with fresh water, and even immersed in this water, may be detonated with certainty by the detonation of a dry primer in contact with it."

Under heading 4, two experiments were made successfully as described immediately above, using salt water instead of fresh. The final experiment and the conclusion of the Committee are given in the report as follows: "Finally, on Oct. 22, we took five discs, coated one for a priming disc, lashed the five discs together, inserted a detonator in the priming disc, and anchored the whole as a mine in the harbor, the submergence being ten feet. Although wholly unprotected by a case, on firing the mine was detonated and the intensity of the explosion was as great and the disturbance of the water was slightly greater than that caused by an exercise torpedo. Hence we conclude that gun-cotton which is completely saturated with salt water, and even immersed in this water, may be detonated with certainty by the detonation of a dry primer in contact with it."

One result of these experiments, though based upon qualitative observations only, and not quantitative, is worthy of remark, as it is in contradiction to the statements of the books. The Committee were "led to the conclusion that the gun-cotton is a more efficient destructive agent as the percentage of water increases."

How much moisture may the priming disc of gun-cotton contain and yet detonate wet gun-cotton with certainty?—Some of the results of the research given immediately above applied to this investigation, so the Committee proceeded at once to experiment with primer discs containing from 10 per cent. of moisture up. The method was to place the moistened primer on a block of gun-cotton which was wholly saturated, the entire system resting on an armor plate. Detonation was shown by the impression on the plate.

Twenty-six experiments were made. The first five, where the primer had 11.96 per cent. of moisture, or less, were successful. Thereafter there were only three isolated detonations, the primers containing 12.77, 14.09 and 15.13 per cent. moisture respectively; and the last nine, with percentages of 15.74 and above, were uninterrupted failures. Commenting on these results the Committee say: "Whenever the primer block detonated, the wet block was detonated; when the primer was simply broken up and burned, the wet block was not detonated. This was the case in each of the experiments marked failed. . . . . This, however, appears certain, that whenever the priming block, no matter what per cent. of moisture it may contain, is detonated it will detonate wet gun-

cotton in contact with it with certainty; and that, in these trials, there were no failures when the per cent. of moisture was below 12 per cent. of the mass."

What is the minimum of dry gun-cotton necessary to detonate a certain quantity of gun-cotton, using the regular detonator?—The report of the Committee says: "The first series of experiments was made by using cylindrical cores cut from the centres of discs of gun-cotton, or slices taken from 2-inch service blocks of gun-cotton, for primers, all being air-dried. These primers were placed on top of a service block of gun-cotton which had been thoroughly saturated with water by soaking in a trough for some hours. The wet block was then placed on an anvil consisting of two 1-inch wrought-iron plates placed one on the other and firmly supported on iron beams, and a service detonator was then inserted in the dry primer and fired.

"It has been shown by numerous experiments on this and similar anvils here that when a single service block of gun-cotton is detonated on the anvil, it will produce a deep indentation in the upper plate; also that when wet gun-cotton is detonated in the open, it gives off a cloud of black smoke, while dry gun-cotton, under the same circumstances, gives a cloud of white or nearly colorless smoke. Again, when the gun-cotton failed to be detonated, the material was found scattered about the firing point in the form of powder.

"As the primers used in these experiments detonated in every instance, the facts noted above were used as a criterion to determine whether or not the wet gun-cotton was detonated. Air-dried primers and service detonators were used in all the experiments described in this report."

The results of twelve experiments follow, in which 10 ounces of wet gun-cotton were used in each instance, the primers weighing from 432 to 2253 grains. The wet gun-cotton detonated when the primers weighed 1373 grains or more, and failed to detonate when the primers weighed 1281 grains or less.

Another series of eleven experiments, in which ½-inch air-dried service primers were used, the other conditions remaining as before, gave the following results: With primers weighing from 1219 to 1296 grains the wet gun-cotton failed to detonate; primers weighing 1342 and 1373 grains respectively caused detonation; while in two

cases in which the primers weighed 1312 grains, and two in which they weighed 1404 grains, one detonation and one failure occurred in each instance. The failure with the 1404 grain primer is the only anomalous result.

The report continues: "It was thought that possibly the primer might act more efficiently if it were placed in the centre of the mass of wet gun-cotton than it did when placed upon it. Consequently a quantity of blocks were taken and saturated with water and then cylindrical cores were cut from the centres of these blocks by means of a jig-saw. The whole was thoroughly dried and weighed, the outer part of the block saturated again with water, the dry core inserted and the whole fired as in the previous experiments."

Of the eight trials none were successful. The greatest relative weight of wet to dry gun-cotton was 3750 to 1003, and the least 2700 to 1250; in two cases the primer weighed 1281 grains.

"These results confirmed the preceding ones as to the minimum limit in the open where but a single wet block, or less, was employed. Experiments were then made to determine if the minimum quantity ascertained above would cause the detonation of more than 10 ounces of wet cotton in the open."

In these experiments a 1312-grain primer detonated 20 ounces and failed to detonate 30 ounces of wet gun-cotton, while 1358 grains did detonate 30 ounces.

Continuing, the report says: "It was thought probable that if the gun-cotton were strongly confined, a smaller mass of dry gun-cotton might serve to detonate wet gun-cotton than was found necessary for use in the open. To test this point, charges were fired in experimental iron torpedo cases* . . . . These cases were charged as described below and were suspended from a buoy 200 feet from the Ferry Pier, the water being about six fathoms in depth, and the torpedoes immersed as described. The results were as follows:

Weight of Wet Gun-cotton. Ounces.	Weight of Primer. Grains.	Depth of Immersion. Feet.	Result.
40	1420	10	Wet gun-cotton detonated.
44	1312	10	" " failed.
40	1389	6	" " detonated.
40	1296	6	" " failed.

* These were of special design.

"In the experiments reported 'wet detonated' there was a large body of water thrown up, which was followed later by a second crater of turbid water, evidently deeply colored by mud from the bottom; there was a very heavy report; the leading wires were very badly cut; and no parts of the cases were recovered. In experiments reported 'wet failed' there was only a slight disturbance of the water and no second crater; there was only a slight report; the leading wires were practically intact; and parts of the case were recovered.

"These results show that, at least so far as these experiments are concerned, no better effect is produced by confinement than by exposure in the open, and the mass of dry gun-cotton to be employed in the primer cannot be reduced.

"In conclusion we would state that, as the result of our experiments, we find that 1312 grains (3 ounces or 85 grams) is the minimum quantity of dry gun-cotton which can detonate wet gun-cotton. As shown in the study of the other topics assigned us, so we find in this, that the *minimum* quantity cannot always be depended upon to do the work."

Appended to the report were the results of the weighings of twenty square service primers, averaging 1147 grains, and twenty round ones, averaging 1319 grains, together with the following remarks: "The results above suggested naturally the testing of these very small priming charges when used with masses of wet gun-cotton such as are used in practice. For this purpose two service torpedoes (pattern *D*) were used. One was loaded precisely as for service use, and therefore contained sixteen $\frac{1}{2}$-inch air-dried primers (or about 40 ounces of gun-cotton). The other contained the usual charge of wet in the outer case, while the inner case was filled with fifteen $\frac{1}{2}$-inch primer blocks which were saturated with water, and one $\frac{1}{2}$-inch block which was air-dried. The latter was the fifth block from the top in the primer case, and was consequently surrounded by and in actual contact on both sides with wet blocks. For this reason a slightly greater quantity than the minimum weight found above was employed. The dry block weighed 1389 grains (3.18 ounces or 90 grams), being 77 grains (.18 ounce or 5 grams) heavier than the minimum.

"The two torpedoes, charged as thus described, were arranged in series and immersed in about eight feet of water off the sea-wall

The two torpedoes were about forty feet apart and were on a line parallel with the sea-wall. The torpedoes were exploded simultaneously, and they both threw up magnificent columns of water which were very nearly similar in form and dimensions, any advantage that was perceptible to the naked eye being in favor of the torpedo which was primed with the 3.18 ounce charge of dry."

To determine the adaptability of gun-cotton in the frozen state to torpedoes.—The first work undertaken by the Committee in charge of the experiments was to prove satisfactorily that frozen gun-cotton cannot be detonated by the use of the service detonator alone, but can be by the aid of dry gun-cotton primers used with the detonator.

Experiments were also made to discover the effect of exploding gunpowder igniters with frozen gun-cotton alone, and also with frozen gun-cotton and one or more priming blocks of dry gun-cotton. In no case did detonation ensue.

The final experiments were made with iron cases filled as follows:

I. One dry disc and three wooden discs.
II. One " " " three " "
III. One " " " three frozen "
IV. One " " " three " "
V. Four dry discs.
VI. One dry disc and three frozen discs.

These were fired in pairs, joined in series, and suspended ten feet below the surface from buoys anchored fifty feet apart in five fathoms of water.

Shells I. and III. were first fired with the following result, quoting the report: "The height to which the water was thrown was estimated to be about four times as great over shell No. III. as over shell No. I."

Shells II. and VI. were next fired. Result: "The column of water and area of disturbance was markedly greater over shell No. VI. No smoke nor fumes were developed, there being an entire absence of visible fumes from frozen gun-cotton."

Lastly, shells IV. and V. were fired. Result: "Equal columns of water and equal areas of disturbed water over shells. No fumes observed."

The report closes with these remarks: "From the results of

experiments with frozen gun-cotton the Committee are of the opinion that it can be detonated by dry gun-cotton, and that it cannot be detonated by fulminate of mercury alone.

"In conclusion we would state that the foregoing experiments have convinced us that gun-cotton in the frozen state can be detonated in the same manner as wet gun-cotton—that is, by a dry primer—and in no other way; and that its explosive effect is practically equal to that of unfrozen gun-cotton, weight for weight.

"In view of this property of gun-cotton, its adaptability to naval uses, and especially to torpedoes, is greater than that of other high explosives, inasmuch as it is rendered in no way inoperative or unreliable by the severe cold of the winter months in our Northern latitudes."

The gun-cotton used came from Stowmarket, England, in 1884, was carried on the Greeley Relief Expedition, and in the autumn of 1884 was stored in the magazine on Rose Island, near Newport, where, in the three winters intervening between that time and the experiments, it had frozen and thawed several times, no doubt. The blocks that were frozen for experiment were first moistened with carbolic acid and carbonate of soda. The detonators used were the service pattern, containing 35 grains of fulminate.

To ascertain the length of time a gun-cotton torpedo may remain primed under service conditions and yet be certain to explode.—In the carrying out of this research, the Committee began air-drying the primers May 21, 1887, using for this purpose gun-cotton consisting of split discs which presented many rough and irregular surfaces, and were thus well calculated to absorb moisture. On May 27, these primers were weighed, placed in the cans, and inserted in the torpedoes. Ten torpedoes were experimented with, and the primers were weighed on June 11 and thereafter weekly until August 27. Two torpedoes were fired June 21, after an interval of twenty-five days; two on July 4, after an interval of thirty-eight days; two on August 5, after an interval of seventy days; and finally the last four were fired on August 27, ninety-two days after priming. Of the last four torpedoes the percentages of moisture gained during three months were 0.84, 0.70, 0.96, and 0.83 respectively.

The Committee close their report by saying: "The torpedoes were all exploded in about 1½ fathoms of water, being placed on the

bottom, and they threw up tremendous columns of water, showing complete detonation. They were fired by the usual service methods.

"From an inspection of these results it will be seen that we have proved beyond question that gun-cotton torpedoes may remain primed under service conditions for three months and yet be certain to explode completely when fired; and, from a consideration of the fact that none of the primers gained one per cent. of moisture during the three months' exposure, and also from the consideration of certain results already obtained in the study of Topic 8, we are of the opinion that the torpedo might remain serviceable, so far as the dryness of the primers is concerned, for some years."

How long an exposure of an imperfectly closed exercise torpedo is necessary to drown the dry primer charge of gun-cotton?—The data of some experiments made in prosecuting another investigation showed that 15 per cent. of fresh water may be absorbed in 19 seconds, while 19.28 per cent. were absorbed in 1 minute and 19 seconds, more than enough to prevent detonation by a detonator alone, and so rendering a dry primer useless. Salt water takes longer to penetrate, and other data of the same investigation show that it takes considerably over a minute to have a sufficient amount of water absorbed to render the primer insensitive to a detonator, which point may be taken as 15.61 per cent. In these experiments, however, the submergence was slight.

The real tests were made with exercise torpedoes. There are two ways in which sound torpedo cases may be rendered leaky, and both have been observed at the Station after complete or partial failure to explode. "One of these ways consists in jamming the friction plate, or removing it altogether. Then, when the water cap is set up, it fouls the lips of the split gland and stretches them apart so as to leave an opening through which the water can penetrate. The other consists in using a hard gasket, or no gasket whatever, or in cocking the cover so that the seven threads are not entered fair."

Experiments were conducted in torpedo cases having each of these defects. When the gland was faulty, two minutes' submergence at the wharf showed a gain of 11.33 per cent. of water in the primer (10.18 per cent. contained); and five minutes' submergence showed a gain of 20.23 per cent. of water (16.83 per cent. contained). When a solid gland was used but the cover cocked, the

same times of immersion gave 5.91 per cent. gain (5.58 contained), and 16.00 per cent. gain (14.34 contained), respectively. With faulty glands the wetting was most complete about the detonator hole and least about the exterior of the discs. With cocked covers the reverse was the case. The former is evidently much the more serious, as the saturation is greater about the wetted parts than throughout the mass.

The final experiments were with two cases; one with the lips of the gland separated, the other with the cover cocked. These were put in the hands of a crew of seamen gunners, who treated them in exactly the same way at exercise as they did the torpedoes that were fired. They were each, therefore, immersed three times: once while shipping on the spar; once while testing; and once in going through the motions of firing. The former was found to have gained 41.15 per cent. (29.15 per cent. contained), and the latter 23.55 per cent. (19.06 per cent. contained).

In discussing these results the Committee say in their report: "It will be observed that all these experiments were made with torpedo at rest in the water, while in the actual practice, especially when backing the launch, a strong current of water is forced against the opening in the case.

"From our experiments, then, we conclude that five minutes' exposure of an imperfectly closed torpedo case is sufficient to drown the dry primer charge of gun-cotton if the torpedo is at rest; but if the launch is backing, one minute's exposure, and perhaps less, will be sufficient."

To determine the influence of the relative position of gun-cotton charge and target by exploding the charge in contact with the target and at small distances from it.—In this research thirty experiments were made by exploding charges of gun-cotton (weighing from 320 to 339 grams each) over wrought-iron plates which rested upon an anvil of armor plates. The first charge was laid directly on its plate. Each succeeding charge was removed from its plate one-quarter of an inch further than the preceding one by the interposition of a stool whose top was a ¼-inch wooden diaphragm, the size of the iron plate, resting upon four legs at the corners; the length of the legs was regulated to give the proper distance of the charge. The diaphragm had a round hole in the middle to permit the gun-

cotton to act directly on the plate. Unfortunately the plates available were not all of the same thickness, varying from $\frac{1}{2}$ to $\frac{11}{32}$ inch, but the error was minimized by presenting the thinner plates to the more distant charges.

The data of the experiments were given in full tabulated form in the report which says: "In general terms it may be stated that the farther the explosive is removed the less the effect."

The circle of depression caused by the shape of the gun-cotton disc was found to disappear at about $2\frac{1}{4}$ inches, while at $7\frac{1}{4}$ inches the general depression was very slight, and the scoring caused by the detonator slight and widely dispersed.

The curious effect was noted that the upper ends of the stool legs were uninjured, while the lower ends, which rested on the plates, were badly broomed and crushed. The radial deposits of residue, which were very plainly marked on the plates nearest the charge, were gradually extended during the experiments until they had a diameter of over three feet on the armor plate in the last experiment, where the charge and plate were separated by $7\frac{1}{4}$ inches.

Beyond the general result as stated above, the Committee were unable to deduce the law governing the change in effect produced as the distance increases, because of the flexibility of the supports and variations in the factors entering into the problem.

The report closes with an extract from an article upon "Compressed Gun-Cotton," by Lieut. Max Von Forster, whose experiments led him to conclude as follows: "With an air space between the gun-cotton and the object to be destroyed, the effect is very much reduced. With a greater air space the effect produced by gun-cotton of 1.1 specific gravity does not differ materially from that produced when the specific gravity is 1.3."

To determine the best method of measuring the relative efficiencies of various explosives.—For measuring the relative efficiencies of different samples of gun-cotton, the Committee recommended the continuation of the method previously used at the Station. In this the deformations of leaden discs of standard size (compressions and extensions) afford the means of judging of the relative efficiency. The discs of lead rest on a solid anvil of iron two feet square and six inches thick, which itself rests on a solid foundation of broken stone and cement. Above the lead comes a disc of Norway iron,

and finally on that the gun-cotton disc and detonator. All are arranged with their axes in one vertical line. All bearing surfaces are smoothed and trued, as well as the cylindrical surfaces of the discs of iron and lead. These latter should not depart in weight from a standard by more than twenty and ten grams, respectively. The dimensions of the lead discs are—diameter, $3\frac{1}{2}$ inches; height, 2 inches. Of the iron discs—diameter, $4\frac{1}{2}$ inches; height, $2\frac{1}{2}$ inches. This method allows gun-cotton to be tested in the condition in which it is used and issued to the service.

For explosives in the liquid or pulverized state the method of Trauzl is favorably mentioned.

Can saltpetre, nitric acid, or chlorate of potash be detonated separately by means of fulminate of mercury?—The official report of the Committee says: "From the results of these experiments we conclude that neither saltpetre, nitric acid, nor chlorate of potash can be detonated separately by means of fulminate of mercury."

What are the permissible limits of electrical resistance in service fuzes and detonators?—Fifty-seven experiments were made in this research and the results were embodied in a report from which the following extracts are taken: "In fixing the limits of electrical resistance for fuze bridges, the service for which they are intended and the firing apparatus to be used with them must be taken into consideration.

"The ordinary uses to which electrical fuzes, detonators, and cannon primers are put in the service at the present time are the firing of a single torpedo from a boat, one to four torpedoes from a ship, or a broadside battery. Ten may be considered as the maximum number of guns in the broadside of any ship at present (1887) in our service, and the introduction of high-powered guns will probably decrease this number. . . . ."

"It was therefore decided that a fuze bridge of such resistance that ten of them arranged in series might be readily and quickly fired by the *C* machine would best answer the requirements of the service. On this basis the experiments were conducted.

"Farmer's *C* machine, having an average electro-motive force of 8 volts and an internal resistance of 4 ohms, has generally been considered as capable of firing from 8 to 10 fuzes of standard resist-

ance (.62 ohm to .68 ohm, both inclusive) arranged in series, or a single fuze through 1500 feet of Siemens' cable such as is now used in the service. Using the standard bridge of iridio-platinum wire (90 per cent. platinum, 10 per cent. iridium) $\frac{3}{16}$ inch long and .002 inch diameter, a current of .6 ampère, which gives a hot resistance of 1.15 ohms to the bridge, is necessary to instantly fire gun-cotton, which is used as priming. Neglecting the resistance of leading wires, the *C* machine is found theoretically capable of firing 8 standard fuzes arranged in series. It may be stated that a less current, as .5 ampère, is sufficient to fire gun-cotton, but requires a sensible time.

"During the experiments it was found to the satisfaction of the Committee that the *C* machine would practically fire ten fuzes of the standard resistance, arranged in series, at apparently the same instant. In twelve experiments of this nature, whether the bridges were made up into igniters or simply primed with gun-cotton, there were no failures. When a bridge of .59 ohm resistance, or less, was introduced into the series there were frequent failures; though, as a rule, when the resistance did not vary much from the standard, all the bridges fired. The same may be said of bridges having a resistance greater than standard.

"The Committee has not been able to explain the cause of failure in any special case, but a general explanation may be given as follows: In the manufacture of bridges of any standard resistance, variations in resistance may be due to:

"1. Errors in measurement of length of bridge.

"2. Difference in amount of solder used to fasten ends of bridge.

"3. Solder or foreign material adhering to the bridge at the middle or near ends.

"4. Errors in measurement of bridge resistance, due to differences in temperature and humidity of atmosphere.

"These errors are to a certain extent unavoidable, but are reduced to a minimum when an experienced workman is employed in the manufacture of the fuzes. It will be seen from the above that a bridge of a certain length may have the same resistance as a longer one having a greater amount of solder at its ends, or solder or foreign material at its middle or near the ends; also that a bridge having a certain resistance at the time of measurement may have greater or less resistance when required for firing. Bridges having the same

resistance but differing in accuracy of construction may therefore require different conditions for firing, and bridges of exactly the same construction, measured at different times, may have different resistances by measurement. Moreover, in any experiments where a (hand) dynamo machine is used, differences in electro-motive force must occur owing to the variations in turning the crank. Like variations in electro-motive force will occur in the use of a battery which is not constant. Far better results were obtained when the bridges were simply primed than when made up into igniters. This is explained as follows: When igniters are used the bridges which are first raised to the required temperature are broken by the explosion of the igniters, thus preventing the others from firing through delayed action. When simply primed with gun-cotton, the bridges are seldom burned off, and a continued turning of the crank of the machine is only necessary to fire all.

"As a result of their experiments the Committee are of the opinion that bridges of the wire now in use, having an electrical resistance of not more than .70 ohm nor less than .60 ohm, are best adapted to the requirements of the service. A somewhat smaller limit should be adopted as an element of safety, because errors are likely to occur in the measurement of resistances from the causes heretofore stated, and because certainty of action is the most important consideration in torpedo practice. The present standard bridge appears to answer all the requirements; and, if the fuzes be made by an experienced workman, little or no waste will result from its adoption. To conclude, the Committee are of the opinion that the present standard bridge, having an electrical resistance of .62 to .68 ohm, both inclusive, is the best both theoretically and practically, and do therefore recommend that its use in the service be continued."

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE ORIGIN AND WORK OF THE DIVISION OF MARINE METEOROLOGY, HYDROGRAPHIC OFFICE.

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[Read before the Meteorological Congress of the World's Congress Auxiliary of the World's Columbian Exposition.]

The Division of Marine Meteorology in the Hydrographic Office of the U. S. Navy Department may be strictly said to have had its origin when Lieutenant Maury became the Superintendent of the U. S. Naval Depot and Observatory in September, 1844.

Lieutenant Maury's energies were almost entirely devoted to the hydrographic and meteorologic subjects, and he took immediate steps to collect information from the log-books of men-of-war and merchant vessels for the preparation of charts to show the prevailing winds and currents, their limits and general characteristics, the best sailing routes, the limits of fog, field ice, icebergs and rain areas, all the physical features of the ocean, the feeding ground of whales, and all facts of interest or value to mariners.

These charts are known as Maury's "Wind and Current Charts." They include: Track Charts, Trade Wind Charts, Pilot Charts, Whale Charts, Thermal Charts, and Storm and Rain Charts.

As soon as merchant mariners understood the object and nature of this work they readily forwarded their log-books for examination, and have ever since promptly furnished all information in their power. Indeed, the voluntary co-operation of the mariners of all nationalities in developing the science of marine meteorology deserves the highest praise and our most profound gratitude.

Lieutenant Maury was Superintendent for 17 years, 1844 to 1861, during which he published the 7 series of Wind and Current Charts, together with 8 volumes of Sailing Directions, containing elaborate articles on Ocean Meteorology and nautical information.

The Track Charts, or "A" series, comprise the North Atlantic Track Charts, in 8 sheets; the South Atlantic Track Charts, in 6 sheets; the North Pacific Track Charts, in 11 sheets; the South Pacific Track Charts, in 9 sheets; and the Indian Ocean Track Charts, in 11 sheets. They show the frequented parts of the ocean, the general character of the weather and wind, and the force and direction at the different seasons of the year. They were compiled by Lieutenants Whiting, Humphreys, Porter, Wyman, Balch, Gibbon, Beaumont, Aulick, Welch, Temple, Wells, Fillebrown, Badger and Woolsey, and Professors Flye and Benedict of the U. S. navy.

The Trade Wind Charts, or "B" series, by Lieutenant De Haven, consist of one sheet of the Atlantic; besides which there is one sheet, a Trade Wind and Monsoon Chart of the Indian Ocean, by Lieutenants Guthrie, Newcomb, Van Zandt, Stout and Houston. These show the limits, extent and general characteristics of the trade wind regions, together with their neighboring zones of calms.

The Pilot Charts, or "C" series, comprise the North Atlantic, in 2 sheets; the South Atlantic, in 2 sheets; the Brazil, in 1 sheet; the Cape Horn, in 2 sheets; the North Pacific and South Pacific Pilot Charts. The Pilot Charts of the Indian Ocean are included in those of the Pacific. The officers employed on these charts were Lieutenants Ball, Herndon, Dulany, Harrison, Forest, Wainwright, Guthrie, De Koven, Deas and Fitzgerald, Passed Midshipmen Davenport, Powell, Balch, Roberts, De Krafft, Wooley, Jackson, Murdaugh, Semmes, Wells, Lewis, Brooke, Johnson and Terrel, and Professor Benedict. These charts show in every square of 5 degrees the direction of the wind for 16 points of the compass that will be probably found in that square during each month of the year, based upon the number of times the wind was reported to have been from that direction in former years; a time was a period of 8 hours.

The Thermal Charts, or "D" series, include the North Atlantic Thermal Chart, in 8 sheets; the South Atlantic Thermal Chart, in 6 sheets; the North Pacific Thermal Chart, in 11 sheets; the Indian Thermal Chart, in 11 sheets (not completed). These charts were the work of Lieutenants Gant and Gardner, and Professor Flye.

They show the temperature of the surface of the ocean wherever and whenever it had been observed. The temperatures are distinguished by colors and symbols in such a manner that mere inspection of the chart shows the temperature for any month. The four seasons of the year are distinguished by the symbols. Isothermal lines for every 10 degrees of surface temperature are also drawn on these charts.

The Storm and Rain Charts, or the "E" series, comprise those of the North and South Atlantic, each in one sheet. They were compiled by Lieutenants W. R. Taylor, Ball, Minor, Beaumont, Guthrie and Young. They show in every square of 5 degrees the number of observations had for each month, the number of days in which there was rain, a calm, fog, lightning and thunder, or a storm and the quarter from which it blew.

The Whale Charts, or the "F" series, are in 4 sheets, for the whole world. They show where whales are most hunted, in what years and months they have been most frequently found, whether in shoals or stragglers and whether sperm or right. These charts were compiled by Lieutenants Herndon and Fleming, and Passed Midshipmen Welch and Jackson.

The Physical Map of the Ocean was not completed.

Some idea of the work accomplished can be formed from the fact that 200,000 copies of the "Wind and Current Charts" and 20,000 copies of the "Sailing Directions" were issued gratuitously to the masters of merchant vessels who had furnished information.

One of the most important historical events connected with Maury's meteorological work was the meeting of the first Meteorological International Congress.

The Maritime Conference held at Brussels for devising a Uniform System of Meteorological Observations at Sea, met at the residence of the Belgian Minister of the Interior on the 23d of August, 1853, and adjourned on the 8th of September, 1853.

The Governments participating were represented by the following officers, viz.:

Belgium, by A. Quetelet, Directeur de l'Observatoire Royale; and Victor Lahure, Capitaine de Vaisseau, Directeur Général de la Marine.

Denmark, by P. Rothe, Capt.-Lieut. R. N., Director Depot Marine Charts.

France, by A. Delamarche, Ingénieur Hydrographe de la Marine Impériale.

Great Britain, by F. W. Beechy, Captain R. N., F. R. S., etc., and Henry James, Captain Royal Engineers, F. R. S.

Netherlands, by M. H. Jansen, Lieutenant Royal Navy.

Norway, by Nils Ihlsen, Lieutenant Royal Navy.

Portugal, by J. de Mattos Correa, Capt.-Lieut. R. N.

Russia, by Alexis Gorkovenko, Capt.-Lieut. Imperial Navy.

Sweden, by Carl Anton Pettersen, First Lieutenant Royal Navy.

United States, by M. F. Maury, LL. D., U. S. Navy.

At the first session of the Conference Mr. Quetelet was made President, and Lieutenant Maury was called upon to explain the object of his mission, which he did in the following words:

"*Gentlemen:*—The proposal which induced the American Government to invite the present meeting originated with the English Government, and arose from the communication of a project prepared by Captain Henry James, Royal Engineers, by order of General Sir John Burgoyne, in which the United States Government was invited to co-operate.

"Nineteen stations had been formed by the English authorities upon a uniform system, and the direction of the observations confided to the immediate supervision of the officers in command of the respective stations. In the United States, meteorological observations had been made since the year 1816.

"The American Government sympathized with the proposal of the English Government, but said: Include the sea and make the plan universal, and we will go for it. I was then directed to place myself in communication with the ship-owners and commanders of the navy and mercantile marine, in furtherance of the plan.

"With a view, however, of extending still further these nautical observations, the Government of the United States decided upon bringing the subject under the consideration of every maritime nation, with the hope of inducing all to adopt a uniform log-book.

"In order to place the captains navigating under a foreign flag in a position to co-operate in this undertaking, Mr. Dobbin, Secretary of the Marine Department at Washington, has instructed me to make known that the mercantile marine of all friendly powers may, with respect to the Charts of the Wind and Currents, be placed on the same footing as those of the American marine; that is to say, that every captain, without distinction of flag, who will engage to keep his log during the voyage upon a plan laid down,

and afterwards communicate the same to the American Government, shall receive, gratis, the Sailing Directions and Charts.

"It has, consequently, been suggested to the captains that they should provide themselves with, *at least*, one good chronometer, one good sextant, two good compasses, one marine barometer, and three thermometers for air and water. I make use of the expression *at least* because the above is the smallest number of instruments with which a captain can fulfil the engagements he contracts upon receiving the charts. Foreign flags will thus enjoy the advantage of profiting at once by all the information collected up to this time. You will not fail to observe, gentlemen, that the observations made on board of merchant vessels with instruments frequently inexact are not to be relied upon in the same degree as those made where the instruments are more numerous and more delicate, and the observers more in the habit of observing. The former, however, from the fact of their being more numerous, give an average result, which may be consulted with advantage; but the observations made on board the ships of the navy, although fewer in number, are evidently superior in point of precision.

"The object of our meeting then, gentlemen, is to agree upon a uniform mode of making nautical and meteorological observations on board vessels of war. I am already indebted to the kindness of one of the members present, Lieutenant Jansen, of the Dutch Navy, for the extract of a log kept on board a Dutch ship of war, and which may be quoted as an example of what may be expected from skillful and carefully conducted observations. In order to regulate the distribution of the charts which the American Government offers gratuitously to captains, it would, in my opinion, be desirable that in each country a person should be appointed by the government to collect and classify the abstracts of logs of which I have spoken, through whom also the charts should be supplied to the parties desirous of obtaining them."

The Conference met daily and continued its sessions until the 8th of September. The Conference devoted itself to the consideration of the best form of a meteorological register for the use of vessels of war; every detail was carefully discussed and two forms of "Abstract Logs" were adopted, one of which was an abbreviated form for the use of the merchant marine. These forms are practically the same as are in general use to this day. They consist of a series of columns

in which are to be recorded the ship's position, the direction and rate of current, observed magnetic variation, direction and force of the winds, barometer with attached thermometer, dry and wet bulb thermometers, forms and direction of clouds, proportion of clear sky, hours of fog, rain, snow, hail, state of the sea, water temperatures at surface and at depths and its specific gravity, and the state of the weather, with an additional column for general remarks.

On a blank page were described the instruments and manner of using them, the corrections for barometer, index error, capacity, capillarity, and height above sea level, when and by whom and with what standard it was compared; the correction to thermometers, and the scale of wind forces, derived from speed sailing by the wind. The Beaufort scale was not then adopted.

The result of this Conference was the establishment of meteorological observations throughout Europe and all over the world on a uniform system, on land as well as on the sea. Prussia, Spain, Sardinia, the free cities of Hamburg and Bremen, Chili, Austria, and Brazil, joined the others in this co-operative work. It was decided to carry on these observations in peace and in war, and in case of capture the abstract log was to be held sacred.

At the close of the Congress Maury returned to Washington laden with honors. Many of the learned societies of Europe elected him an honorary member; orders of knighthood were offered him and medals were struck in his honor. Humboldt declared he had founded a new science.

In 1856 Maury published his work, "Physical Geography of the Sea," which has been translated into German, French, Dutch, Spanish, Norwegian and Italian. Maury instituted the system of deep sea sounding, and was the first to suggest the establishment of telegraphic communication between continents by submarine cables. The first cable was laid on the line indicated by him.

On the 20th of April, 1861, the State of Virginia passed the Ordinance of Secession. Unfortunately, having been born in that State, near Fredericksburg, on January 14, 1806, Maury felt that his native State demanded his first allegiance, and on that day he resigned his commission, turned all the property at the Observatory over to Lieutenant Whiting, and went to join the Confederates at Richmond. Maury left a number of his writings in unfinished condition, some of which were subsequently published, and when

he offered his services to the Confederate Government he had had no previous arrangement for any position of special honor; but, on the contrary, by leaving the U. S. navy he made a great sacrifice of his personal ambition in order to do what he believed to be his duty to his native State. Only a short time before he resigned he wrote to his friends by all means to stay in the Union, and his resignation was such a surprise, in view of his Union sentiments, that he was accused of all sorts of treasonable and dishonorable conduct, such as the removal of buoys, etc. This was false.

When it became known in Europe that Maury had resigned, the Grand Duke Constantine offered him the post of Superintendent of the Observatory at St. Petersburg to continue his meteorological researches; the French Government also invited him to continue his meteorological work in France, and the Russian and French ministers carried these invitations by flag of truce through the lines.

Maury declined these offers, saying that his country needed his services. He entered the Confederate navy June 10, 1861, and in October, 1862, he established at Richmond the Naval Submarine Battery Service; but before this was far advanced, he was sent to Europe to continue his experiments and to act as one of the Confederate navy agents. He invented an ingenious method of torpedo defence, with which he sailed to put in operation at Galveston, Texas. Upon his arrival at Havana he heard of Lee's surrender, and offered to surrender himself.

In June, 1865, he went to Mexico, where he offered his services to the Emperor Maximilian, by whom he was appointed Director of the Imperial Observatory. Maury elaborated the immigration scheme in Mexico, and was appointed Imperial Commissioner of Immigration, with the idea of making Mexico a home for ex-Confederates, and to develop the resources of that country.

In March, 1866, Maury arrived in England on a special mission, and during his absence Maximilian was overthrown and shot. Maury was received with great honor by scientists and former friends, and, in view of his meteorological work, they sought to repair his fortunes. He found employment by instructing European officers in the use of the torpedo, and he was offered a permanent position in France. But in 1868, the Act of General Amnesty having removed all objection to Maury's return, he accepted the appoint-

ment of Professor of Meteorology in the Virginia Military Institute at Lexington, where he was installed in September, 1868. During the last five years of his life he made a meteorological survey of the State of Virginia, and by numerous lectures in different parts of the country he called attention to the importance of meteorological studies in behalf of agricultural interests. Maury died, as he had lived, a Christian, February 1, 1873.

During his life he received the following honors: By the Emperor of Russia, Knight of the Order of St. Ann; by the King of Denmark, Knight of the Dannebrog; by the King of Portugal, Knight of the Tower and Sword; by the King of Belgium, Knight of the Order of St. Leopold; by the Emperor of the French, Commander of the Legion of Honor; while Prussia, Austria, Sweden, Holland, Sardinia, Bremen, and France, struck gold medals in his honor. The Pope sent him a set of all the medals that had been struck during his pontificate as a mark of his appreciation of his labors for science. Maximilian decorated him with the Cross of our Lady of Guadaloupe.

He became Corresponding Member of the Naturkundige Vereenigung in Nederlandsch Indie, Batavia, February 17, 1853; Die Naturforschende Gesellschaft in Emden, March, 1854; Société des Sciences, des Arts et des Lettres de Hainault, 1854; Academie Impériale des Sciences de Russe, St. Petersburg, 1855; Academie Royale des Sciences, des Lettres et des Beaux-Arts de Belgique, Brussels, 1854; New York Lyceum of Natural History, New York, 1865; Philadelphia Academy of Natural Sciences, 1858; Die Gesellschaft zur Beförderung der gesammten Naturwissenschaften in Marburg, 1856; Historical Society of New Jersey, 1856; Historical Society of Tennessee, 1857; Die Gesellschaft für Erdkunde in Berlin, 1858; Gesellschaft der Wissenschaften, Prague, 1858; Director del Observatorio Nacional, Mexico, 1865; Consejero Honorario de Estado, Mexico, 1865; Miembro Honorario de la Sociedad Mexicana de Geografia y Estadistica, Mexico, 1865; Miembro de la Imperial Academia Mexicana de Ciencias, Mexico, 1865; LL. D. of the University of Cambridge, England, 1867. He was also a member of several other learned bodies of which the records have been lost.

With all these honors Maury's name will ever be held in the highest esteem by mariners of all nations, by the U. S. Navy, of

which he was one of its most brilliant officers, and by the American people, who are proud of his achievements.

This Congress of Meteorology must also render to the name of Maury a tribute of most profound gratitude as the founder of the science of meteorology, and the highest honor for his great researches in every department of this science.

Commander J. M. Gillis became Superintendent of the Naval Observatory when Maury resigned, and on the 5th of July, 1862, it was transferred from the Bureau of Ordnance to that of Navigation. Meteorological observations were continued, but the elaborate system of co-operating with the merchant marine was suspended until after the war.

Rear-Admiral C. H. Davis became Superintendent on April 28, 1865, and June 21, 1866, the U. S. Hydrographic Office was established, with the duty of making charts and publishing "Sailing Directions" and meteorological information. Very little progress was made with meteorological work during the next five years, beyond the occasional publication of pamphlets on the barometer, thermometer, hygrometer, and general meteorological information in "Sailing Directions."

The Hydrographic Office was reorganized on the 21st of January, 1871, under Captain Wyman, and five separate departments were created, one of which was the meteorological department, the duties of which were defined to be: "To construct Wind and Current Charts, according to adopted forms, and for this purpose to collect and systematically arrange the meteorological data on hand or which may be received; to take charge of all log-books, track charts, remark books, and such other books, charts and papers as may be required in the construction of wind and current charts; to prepare and issue blank meteorological journals, constructed according to the most recent requirements, for the purpose of collecting meteorological data suitable for use in making special and general inquiries into the science; to keep informed on all subjects pertaining to meteorology and physical hydrography."

In 1873 it was decided to again commence the collection of information from men-of-war and merchantmen to accumulate matter for a new edition of Maury's charts, and requests for such data were sent out to the navy and merchant marine. The method was to collect data in squares of 5 degrees of latitude and 5 degrees of

longitude for each month a vessel might be in one of the squares, and also for each fraction of a month.

Lieutenant T. A. Lyons was in charge of the meteorological division and, assisted by a number of other officers of the navy, he compiled the meteorological data collected, and in the course of three years the office published new sets of meteorological charts for the Atlantic and Pacific Oceans, and the work was continued on similar charts for other oceans.

The North Atlantic Meteorological Charts are in 12 sheets, one for each month. They extend from the equator to 60° N. and 10° E. to 85° W., with a sub-chart on the same sheet for the western part of the Gulf of Mexico. In each square are expressed the percentage of the total number of hours of observations of the true compass directions and force of wind, the calms, variables, rain, fogs, moderate and heavy squalls, gales (all winds above the force of 8, Beaufort scale), the mean barometer, thermometer (both wet and dry bulbs), surface temperature and the daily ranges of these instruments.

Blank meteorological journals were issued to masters of all merchant vessels who agreed to keep them and co-operate with the office, in October, 1877; these journals are still being kept by masters of merchant vessels, but in 1887 they were superseded by the forms for Greenwich noon observations. The journals are similar to the abstract log-books adopted by the Brussels Conference. There are four thousand of these journals in this office containing data of great value, which are kept available for the preparation of synoptic charts of all oceans. These will enable the office to publish pilot charts of other oceans similar to those of the North Atlantic.

From 1873 to 1883 the work of the Division of Marine Meteorology was conducted on the lines described for the preparation of the new "Wind and Current Charts" on Maury's plans, revised by Lieutenant T. A. Lyons. Captain S. R. Franklin became the Hydrographer on May 17, 1878, and he was relieved by Captain J. C. de Krafft on July 15, 1880; the latter was assisted by Lieut.-Commander C. D. Sigsbee. Commander J. R. Bartlett was appointed Hydrographer June 30, 1883.

To bring the office in close touch with the merchant marine, branch hydrographic offices were established in 1883 at New York,

Philadelphia and Boston, and were each placed in charge of a naval officer. Mariners were invited to visit these offices to obtain nautical information, to compare their meteorological instruments, and secure the latest hydrographic publications. These offices issued the log-books, blank forms, etc., and were so successful in securing the co-operation of mariners with the office that other branch offices have since been established in all the principal ports of the country, viz.: Baltimore, Norfolk, Savannah, New Orleans, San Francisco, Portland, Port Townsend and Chicago.

Lieutenant S. M. Ackley was in charge of the Division of Marine Meteorology from June, 1883, until June, 1887. In December, 1883, the office commenced the publication of the monthly Pilot Charts for the North Atlantic Ocean. The great practical utility of these charts was demonstrated from the very first, and the work of the division has chiefly been devoted to the publication of these charts. Improvements are constantly being made, and the early issues bear no comparison with those of the present time.

The Pilot Charts are the result of the co-operative work of mariners of all nations, and the number of those who co-operate is constantly increasing. In 1884 there were only 127 observers of the merchant marine, while on June 30, 1893, there were 2844, besides the observers in the navy.

Lieutenant G. L. Dyer relieved Commander Bartlett as Hydrographer June 1, 1888, and was succeeded by Captain H. F. Picking in June, 1889. He was relieved by Lieut.-Commander R. Clover, September, 1890, and the present Hydrographer, Commander C. D. Sigsbee, took charge June 1, 1893. Ensign Everett Hayden, Marine Meteorologist, was in charge of the division from June, 1887, until May 19, 1889, when Lieutenant H. M. Witzel relieved him until January 21, 1892, when Lieut.-Commander E. W. Sturdy took charge until December 15, 1892, when he was succeeded by Lieutenant W. H. Beehler, at present in charge of the Division of Marine Meteorology. The force in the office consists of four nautical experts (graduates of the U. S. Naval Academy in civil life), viz.: Messrs. T. S. O'Leary, R. L. Lerch, R. H. Orr, and H. H. Balthis, a stenographer and a messenger. This force is engaged on the final work of preparing the data and investigating the various problems for the practical presentation of meteorological information to mariners.

The work is conducted under the Hydrographic Office, and all the divisions in that office are concerned in the work. In fact, the Pilot Charts were originally intended merely as a means for inducing the co-operation of mariners in hydrographic work. These charts are presented to observers in exchange for their reports, and the chart has proven to be such a desirable method of communicating hydrographic and meteorological information to mariners that it has become of the greatest value. The work is therefore not so much a scientific study as a practical presentation of facts for the use of practical men. Advantage is duly taken of every new discovery when clearly established, but the investigations are pursued for their practical value and for immediate use.

Under the direction of the Hydrographer the Division of Chart Construction prints the charts, the Division of Sailing Directions supplies the hydrographic information for the Pilot Charts, and the Division of Charts gives notice of the charts published, cancelled and extensively corrected. The Branch Hydrographic Offices issue the forms and publications to mariners, receive and forward their reports, compare and correct their instruments and, by personal visits to vessels in port, secure the co-operation of additional observers. The office also has the co-operation of the U. S. Weather Bureau and, by the system of exchanges, also has access to the reports obtained by the New York *Herald* Weather Service. The keepers of the light-houses and light-vessels of the U. S. Light House Establishment also co-operate, while there are a number of voluntary observers among the keepers of light-houses on the coast of Newfoundland and Labrador who send valuable and timely reports of the ice movement on that coast. Voluntary observers in the West Indies and other islands send valuable reports. A number of foreign meteorological observatories and societies correspond with the office, and the U. S. Consular Service renders valuable aid by forwarding reports and bringing the work to the attention of mariners, by which many additional co-operators are secured. The method of current investigation with bottle papers has brought a great many to assist in the work. On the coast of Ireland bottle papers are frequently found, and many very amusing letters are received. In one the finder requested that if the paper was of any value he thought that the office should send him the price of a pair of boots, as he had lost the only pair he had while standing in the tide examining the document.

From this extensive field the office has naturally collected a vast amount of data, so that it is pre-eminently well equipped to continue the work and extend the system of the North Atlantic Pilot Charts to all oceans, and steps to that end have been taken.

The following is a list of reports received: Trade winds, ice, wrecks, fogs, buoys adrift, whales, meteorological journals, storms, Greenwich noon observations, the use of oil to still the waves, waterspouts, ocean currents, Gulf stream, abstract logs, derelicts, barometer comparisons, curves of self-recording barometers and thermometers, track charts of vessels' voyages, routes of trans-oceanic steamers, sailing routes, reports of deep sea soundings, auroras, thunder-storms, electrical phenomena, and general information.

Blank forms are issued for these reports, which are forwarded to the Hydrographer and, if not acknowledged by the branch office, are answered by him..

In February, 1886, a weekly supplement known as the "Hydrographic Bulletin" was issued, and has been regularly published ever since, for the special use of the U. S. coastwise navigators. It has notices about obstructions, dangers, ice and fog, but does not go into much detail for meteorologic information. 2000 copies are printed every Wednesday.

Upon the receipts of the reports the data are immediately plotted on synoptic charts from which the Pilot Charts are prepared. Reports in foreign languages are translated and utilized. Preparations are now being made to publish these daily synoptic charts.

The Pilot Charts are printed in three colors. The black is a transfer on stone from a regular engraved copper plate of the Mercator's Chart of the ocean. The blue data consist of the meteorological forecasts and routes; they are compiled from the accumulated data on the synoptic charts of previous years and indicate the probabilities based upon experience in this month in previous years.

The red text is furnished the day before the chart is published, and consists of a review of the weather for the previous month up to the date of publication, the storm tracks, fog limits, drifting ice and icebergs, the position of derelicts, wreckage, etc., and in the space over the land in the left-hand corner gives general information of timely interest concerning special reports, storms, currents, use of oil, dangers in the navigation, etc.

Supplements are frequently issued relating to storms, remarkable drifts of derelicts, wreck charts, ocean currents, routes and the use of oil. 4000 copies of the Pilot Charts are distributed monthly.

The Pilot Charts have, perhaps, more than any other agency brought about the general recognition of the value of the use of oil to still the waves, and the masters of hundreds of vessels have reported they were saved from total loss with all on board by the use of oil on seas.

The charts have served to bring about the adoption of regular ocean lanes for transatlantic steamers to minimize risk of collision.

During the past six months the accumulated meteorological data have been arranged and systematically classified, and a card catalogue has been inaugurated by which all marine meteorological information in all the Department libraries is made immediately available. The system adopted is a classification of all the work in three departments—Meteorology, Oceanography and Shipping—each of which is subdivided into a number of divisions, and each division again divided into a number of branches, so that every subject is carded in its proper branch of its division of its department.

A new base plate is being engraved for an improved Pilot Chart which will be designated as a Co-operative Chart for Mariners, in order to emphasize the fact that it is a practical presentation of the meteorological facts reported by co-operating observers.

It is contemplated to largely increase the working force of this division, and it is hoped that the members of this Congress will approve this work and co-operate with the Hydrographic Office by communicating the results of their scientific investigations for the use of practical men.

The Congress is requested to consider the advisability of taking at least one observation each day at the time of Greenwich noon. The 2844 co-operating observers of this office on vessels cruising in all parts of the world take the observations at this time, and if such observations are taken on land as well as at sea, the meteorological conditions all over the world can be seen from daily synoptic charts.

Observations may be taken in addition at other times as at present, and in the Pacific observations at Greenwich midnight are recommended, but there is urgent need for one observation daily at Greenwich noon by each observer.

In preparing this paper I have consulted "Founding and Development of the U. S. Hydrographic Office," by Lieut. W. S. Hughes, U. S. N.; "Memoir of the Founding of the U. S. Naval Observatory," by Prof. J. E. Nourse, U. S. N.; "Life of Matthew Fontaine Maury," by his daughter; "Maury's Sailing Directions"; "Appleton's Cyclopedia of American Biography"; "Annual Reports of the Hydrographer," and official records in the Division of Marine Meteorology.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

A LOOP IN THE TRACK OF AN OCEAN STORM.

By Ensign Everett Hayden, U. S. N.

A storm-track, as usually shown on weather maps and on the well-known Pilot Chart of the North Atlantic Ocean, published by the U. S. Hydrographic Office, represents the path of the centre of the storm; that is, of the point of lowest barometer. This point coincides, in the great majority of cases, with the centre of the whirling winds that make up the cyclone. Anyone who has had regular or even casual access to such publications must have noticed that storm-tracks are sometimes very irregular, and that occasionally an actual loop is represented. The question is often asked whether the facts justify such a track, and undisguised incredulity is sometimes expressed as to the possibility, or at least probability, of such erratic movements. In the case of storms that occur over the land, where regular observations are taken at numerous and well-selected stations, it is very easy to locate the storm-centre at frequent intervals of time and space, and thus, by joining such points in chronologic order, plot the storm-track with unquestionable accuracy. The fact is thus brought out very clearly that the tracks of land storms do often form loops. At sea, however, the data are often too few, or too poorly distributed, to allow of drawing the track with such accuracy, and this necessarily results in the elimination of whatever erratic tendencies the track may actually have been guilty. Occasionally, however, the data are so complete as to allow of a very accurate charting of the storm-track, and it appears that the tracks of ocean storms do really occasionally form loops of this kind—as indeed might naturally be inferred by analogy and by

à priori reasoning based on the general character and movements of such storms.

Upon the Pilot Chart for February, 1893, such a loop was shown in a storm-track west of the Irish Channel, and, question having arisen as to the correctness of my work, I went over the whole subject very carefully again, aided by data received after the Chart went to press, and prepared the following statement, which, proving as it does, in this particular case, a loop in the track of an ocean storm, may be regarded as worthy of study by all interested in the subject. The detailed reports that are appended should be referred to for confirmation of every statement and for the solution of any doubtful point that may arise, and I venture to say that no sailor will ever regret the time that may be required to follow the discussion through from beginning to end, studying not only each report explicitly referred to, but also those not so referred to, in order to verify, to his own entire satisfaction, the fact that the storm-track is correctly represented.

One other question that arose subsequently may well be referred to here, and that is, how does the law of storms apply in the case of such an abnormal track? My answer is that it applies exactly as well as in the case of any other storm. In other words, a vessel encountering the storm has certain shifts of wind and must be guided by the well-known rules for such shifts. In some positions relative to the track the wind may veer gradually from NE. to SE., S., SW. and NW. In other positions it may back from, say, SE. to NE., N. and NW. In still others it may first veer through half a dozen points, then steady, and then back. In each case action must be taken, if possible, exactly as the rules prescribe for wind shifting to the right, or for a steady wind, or for a backing wind, and the navigator need not and will not bother his head as to whether the storm-track is describing a loop or even a figure-of-eight, so long as he is on the right tack according to the wind and the shifts of wind that he himself is experiencing.

The statement referred to is as follows:

HYDROGRAPHIC OFFICE, WASHINGTON, D. C.,
February 9, 1893.

Sir:—In compliance with the Hydrographer's memorandum, referred to me by yourself yesterday, I beg to submit the following statement relative to the track of the storm of Jan. 3–9, '93, west of St. George's Channel.

The positions of the storm centre at Greenwich noon each day are defined quite definitely on our synoptic charts, as indicated by the data regarding wind and barometer plotted thereon. The track is drawn from each of these positions to the next one, care being taken, of course, to examine the conditions as carefully as possible, so as to be sure the storm was continuous within the region and time under consideration. In the case of a storm of any decided severity we generally receive a number of storm reports, in addition to those for noon, G. M. T., and such reports often enable us to plot the track between the noon positions with great accuracy. But in some cases we have less complete information for that portion of the storm-track, and have therefore to rely upon our general knowledge as to the motions of storms under similar conditions. In the case now under consideration, the data were sufficiently complete to draw the track with considerable confidence, and later data (received during the past two weeks) confirm the track as drawn on the February Chart.

To illustrate the way in which the position of the storm centre is determined for noon, G. M. T., a copy of part of our synoptic chart for Jan. 3, '93, is given herewith (Plate I.).

It will be seen at a glance that the wind-circulation as well as the distribution of barometric pressure locate the centre quite definitely at the position marked. Similarly for each succeeding day the centre is located for the time of the chart (Greenwich noon), and the next step is to join these positions by a line that shall represent as accurately as possible the track that the storm centre followed from any one day to the next.

The second of the accompanying maps (Plate II.) gives the track of the storm from Jan. 2–4, inclusive, and the tracks and names of the vessels near the centre of the storm on the 3d and 4th, by means of whose reports the peculiar loop in the storm-track can be explained. The tracks of these vessels, it will be noticed, are from Greenwich noon of the 3d to Greenwich noon of the 4th in each case, or from about 10 A. M., local time, of the 3d, to 10 A. M. of the 4th. The tracks of the Brazilian and La Hesbaye are of special importance, inasmuch as these two vessels passed through or near the centre during the recurve.

Abstracts of the reports of each of the vessels whose tracks are plotted on Plate II. are given herewith, and these data show that the storm centre moved as indicated, and that the track described a loop as the storm recurved from its position on the 3d to its position on the 4th. In a word, the storm approaching from the southward turned to the westward and followed close after La Hesbaye (which vessel had ESE. shifting to N. and NNE. winds), and then moved south and east completely around the Brazilian, which vessel was bound east and had the wind shifting from NE, to N., NW., W., W. by S., WSW., SW., S., S. by E., SSE., SE. No better instance could possibly be selected to illustrate such a case, and, indeed, these two vessels' reports are in themselves sufficient to prove that the storm-track did make a loop. The other reports, however, confirm it in every respect, and the plotted tracks show how complete the data are. An attentive examination of these data, moreover, shows them to be perfectly consistent and reliable.

The report of the State of Nebraska may be referred to further, as it shows that there was another and entirely distinct storm to the north of that vessel, a storm whose track cannot be plotted, for lack of data, but to whose influence the peculiar recurve of this southern storm was doubtless due. It is well known that storms act in this way under just such circumstances, both at sea and over the land, and many good examples might be referred to. To select only two, take the case of the storm over Nova Scotia, March 5th and 6th, '92 (see April Pilot Chart), and the storm over the Bay of Biscay, Oct. 12-16, '92 (see Pilot Chart for November). In each of these cases the facts are indisputable, and the present discussion is valuable as emphasizing an equally good instance of a loop in a storm-track at sea. Very respectfully,

EVERETT HAYDEN,
Marine Meteorologist.

TO THE CHIEF OF DIVISION OF MARINE METEOROLOGY.

ABSTRACTS OF REPORTS.

Belgenland (Bel. S. S.), Capt. Bence. Report by Fourth Officer Doncker. SE. wind, increasing, heavy rain squalls ; lowest bar. noon, 4th, 29.00 (aneroid, as read off); wind. SE. 8, shifting to NE.

Brazilian (Br. S. S.), Capt. Whyte. Report by Lewis Thompson, Second Officer. *Jan.* 3, A. M.—Squally, with rising sea, cloudy weather, wind remaining steady from N. to NNE. 8 A. M.—Wind increased to fresh gale, varying from NE. to N., with high confused sea. Noon.—Strong gale, gloomy, threatening weather, sea very high and cross. Wind about 4 P. M. changing from N. to NW. and W., moderating to fresh gale at 6 P. M. Wind then went to W. by S. 8 P. M.—Wind still moderating and shifting rapidly to WSW., SW. to S. Midnight.—Fresh breeze, S. by E., clear, with passing clouds, sea rough and confused. *Jan.* 4, A. M.—Wind following the above came from SSE. to SE., strong breeze, squally. Lowest barometer, Jan. 3, at 8 P. M., 29.20 (merc., corrected), remaining steady for 3 or 4 hours, rising toward midnight.

The following is a more detailed report :

Jan. 3, 9.59 A. M.—49° 28′ N., 30° 16′ W., N. 7, 29.49, g. q. Fresh breeze since yesterday, wind increasing at midnight to strong NE. breeze. Cloudy ; later, fresh gale, squally ; gloomy and threatening weather, with high sea from NNE. Noon.—49° 31′ N., 29° 08′ W., NNW. 9, 29.26, u. q. r.

(Form 105*b*), 8 P. M.—49° 35′ N., 27° 48′ W., W. by S. 5, 29.20, o. p.

(Form 105), 8 P. M.—49° 30′ N., 28° W. (sic), W. by S., 29.20. Midnight.—49° 43′ N., 26° 52′ W., S. by E. 5, 29.20, b. c.

Jan. 4, 10.22 A. M.—49° 54′ N., 24° 35′ W., SSE. 6, 29.29, g. c. q. At noon yesterday fresh gale, with high confused sea; wind N., changing to NW. and W.; at 4 P. M., strong gale. 6 P. M.—Weather moderating, wind W. to SW., shifting to S.; clear weather. *Jan.* 4, A. M.—Wind freshening from SSE., stormy looking and squally; short broken sea from SE. Between 4 and 8 P. M.—Wind shifted from S. through E. to NW., light breeze. *Jan.* 5, A. M.—Strong breeze, WSW. to SW.; clear weather, wind changing to SSW., cloudy, bar. rising.

Diamant (Nor. S. S.), Capt. Kelterer. *Jan.* 3, 10.08 A. M.—N. 8, 29.55 (aneroid, as read off). Noon.—49° 28′ N., 29° 26′ W., NNE. 8, 29.55 (aneroid, as read off). *Jan.* 4, 9.41 A. M.—NNW. 7, 29.92.

Gladiolus (Br. S. S.), Capt. Wright. *Jan.* 3, 10.20 A. M.—NE. 5, 29.72 (aneroid, as read off). *Jan.* 4, 10.08 A. M.—N. by E. 9, 29.50.

La Hesbaye (Netherlands S. S.), Capt. Ninnes. Report by Chief Officer Eckhoff. *Jan.* 3, 10.21 A. M.—SSE. 5, 29.30 (aneroid, corrected). During past night very strong breeze, with rain showers, from ESE.; very high rolling sea from SSW. *Jan.* 4, 10.02 A. M.—N. to NNE. 9–10, 28.77. Foggy sky with light mist-showers during past night; lowest bar., 28.71 (time and position not stated). *Jan.* 4, midnight.—Wind hauling to N'd.

Memphis (Br. S. S.), Capt. McNeely. Report by Second Officer Burgess. *Jan.* 3, 11.04 A. M.—SE. 7, 29.64 (aneroid, as read off). 3 P. M.—50° 30′ N., 15° 30′ W., SE. 9, 29.26. *Jan.* 4, 10.36 A. M.—S. 6, 29.16. For past 24 hours, fresh gale, high, confused sea, clearing towards noon.

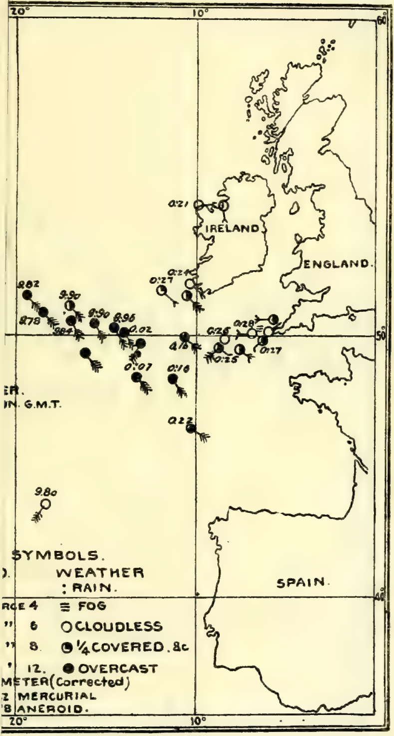
Michigan (Br. S. S.), Capt. Fenton. Report by Fourth Officer Dix. Boston toward Liverpool. *Jan.* 3, 9.57 A. M.—NE. 8, 29.65 (aneroid, corrected). 4 P. M.—NE. by N. 6, 29.75. Midnight.—NNW. 10, 29.31. Fierce gale, overcast, high sea. *Jan.* 4, 4 A. M.—NW. 10, 29.30. Gale showing signs of abating; bar. stopped falling, sky clearer. 8 A. M.—Variable, 3, 29.36. Gale finished, blowing itself out, followed by variable winds, finally settling at ESE., and fine, clear weather. 10.12 A. M.—E. 3, 29.37. This gale commenced with first fall of bar., and increased rapidly, moderating when bar. stopped falling, weather clearing as bar. rose.

Michigan (Br. S. S.), Capt. Layland. Report by Third Officer Forsyth. Swansea toward Philadelphia. *Jan.* 3, 10.08 A. M.—NE. 7, 29.45 (aneroid, as read off). *Jan.* 4, 8 A. M.—50° 29′ N., 29° 28′ W., NNE. 9, 29.25. 10 A. M.—NE. 9, 29.36.

Prodano (Br. S. S.), Capt. Trotter. Report by Second Officer Fison. *Jan.* 3, 4 A. M.—Very heavy hail squall from N., lasting over half an hour. Then sky clear and winds variable, clouds from N'd. 10 A. M.—Light wind setting in from NNW., steadily increasing till 4 P. M., when it was blowing a fresh gale from NNW.; sea getting up very quickly and sky becoming overcast. From midnight till noon of the 6th it blew a whole gale, with tremendous long rolling sea. 4 A. M.—N. 2, 29.81 (aneroid, as read off). 5 A. M.—NNW. 5, 29.65. 6 A. M.—NNW. 11, 29.29. Noon.—NNW. 8, 29.36. 7 P. M.—NNW. 3, 29.47.

Servia (Br. S. S.), Capt. Dutton. Reported by Extra Second Officer Cleere. *Jan.* 3, 10.10 A. M.—NNE. 7, 29.50 (aneroid, corrected). *Jan.* 4, 9.41 A. M.—N. 7, 29.80. The gale commenced on the 3d at SE., veering to E., to NE., and N., finally NNW. (true), blowing hard between NE. and N. at 8 P. M. Continued to blow hard till 5 A. M., 4th, when wind and sea moderated sufficiently to keep ship on her course, she having been hauled up to the N'd of her course for about 12 hours (3 P. M. to 3 A. M.).

State of Nebraska (Br. S. S.), Capt. Brown. *Jan.* 2–3.—Light, unsteady winds, shifting to SE. and increasing. *Jan.* 3, 10.27 A. M.—E. by S. 6, 29.83 (aneroid, as read off). *Jan.* 4, 2 A. M.—53° 04′ N., 29° 10′ W., SW. 7, 29.23 (aneroid, as read off). Wind shifted to NW. *Jan.* 4, 9.56 A. M.—N. 9, 29.43.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' 12.
● OVERCAST
METER (Corrected)
2 MERCURIAL
8 ANEROID.

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Servia (Br. S. S.), Capt. Dutton. Reported by Extra Second Officer Cleere. *Jan.* 3, 10.10 A. M.—NNE. 7, 29.50 (aneroid, corrected). *Jan.* 4, 9.41 A. M.—N. 7, 29.80. The gale commenced on the 3d at SE., veering to E.; to NE., and N., finally NNW. (true), blowing hard between NE. and N. at 8 P. M. Continued to blow hard till 5 A. M., 4th, when wind and sea moderated sufficiently to keep ship on her course, she having been hauled up to the N'd of her course for about 12 hours (3 P. M. to 3 A. M.).

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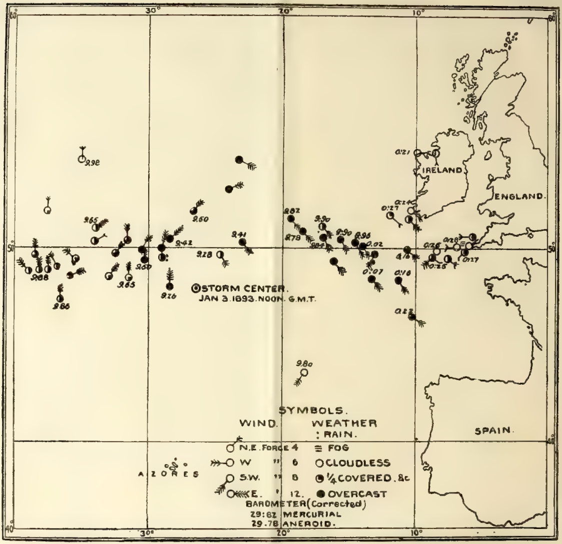
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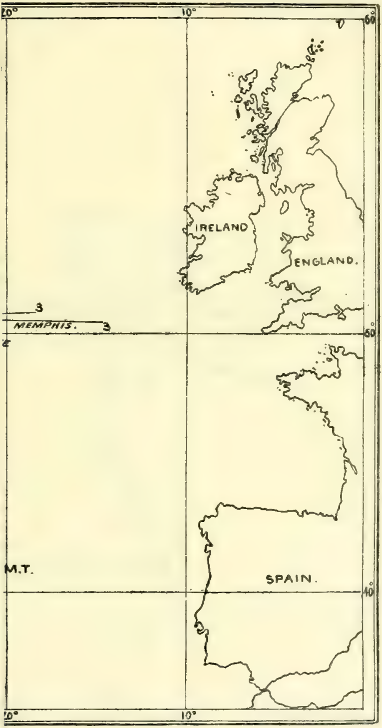
E. " 12.
OVERCAST
BAROMETER(Corrected)
29:82 MERCURIAL
29.78 ANEROID.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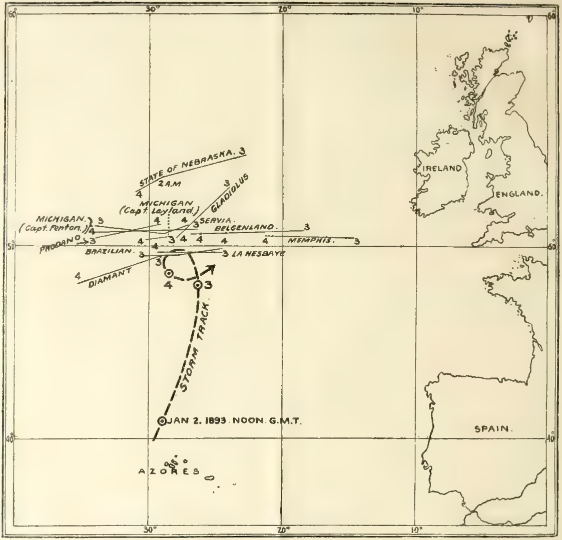
A LOOP IN THE TRACK OF AN OCEAN STORM.



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

THE KRNKA-HEBLER TUBULAR PROJECTILES.

[Reprinted from *United Service Gazette*, August 12, 19 and 26, 1893.]

I.

Professor Hebler, of Zurich, in a recent number of the *Allgemeine Schweizerische Militär-Zeitung*, publishes some highly important details on the results obtained by the adoption of the tubular bullets designed by himself in conjunction with Herr Krnka. We have already, in a previous number, given the results of Professor Hebler's experiments with bullets of an improved pattern of ogival head, which show conclusively that a wide field still exists for enhancing the effectiveness of rifle fire by studying the form of bullet best adapted for neutralizing as far as possible the resistance offered by the atmosphere. In spite of the almost incredible increased ballistic properties shown by the Hebler solid bullets, the Professor did not despair of attaining yet more extraordinary results from the adoption of tubular bullets, the first experiments with which were commenced in 1874. At that time, however, the results obtained were anything but satisfactory, owing to the soft lead, of which the bullets were then made, setting up and becoming deformed by the pressure of the gases before leaving the barrel. The introduction of jacketed bullets, covered with an outer casing of steel or nickel, rendered possible what hitherto could only be regarded as a scientific attempt to minimize the resistance of the atmosphere, more especially as the external envelope and the central tube of the bullet can be made out of one single piece of metal, thus precluding all fear of the missile losing its shape whilst being driven forward along the barrel.

After experimenting with various models, Messrs. Krnka and Hebler decided that the bullet best adapted to overcome the resist-

ance of the air should have the same ogival form in rear as in front; the experiments which are briefly summarized below refer to bullets of that shape. The question of the diameter and shape to be given to the central channel considerably affects the efficiency of the projectiie, since it is clear that if the channel is too small the resistance will only be to a slight extent neutralized, whilst, on the other hand, other disadvantages would arise if it were too large. Messrs. Krnka and Hebler have now adopted a central channel two-fifths that of the diameter of the projectile, widening out to a funnel shape at its base. In order to centre the bullet and to allow of the full pressure of the gases taking effect, a light base cup is fitted, which drops out as soon as the bullet leaves the muzzle of the rifle. This base cup fits into the funnel-shaped portion of the channel and ensures perfect centring of the projectile.

In comparing the ballistic properties of the tubular bullets with those used in the German rifle, 1888 pattern, two kinds were used, which are classed as "heavy" and "light," the former being filled with hardened lead and the latter with zinc, or with an alloy of zinc and copper. The results prove that the "light" bullet is to be preferred, as, although its penetration at all ranges is slightly inferior to that of the "heavy" bullet, its trajectory is flatter, especially at short and medium ranges, whilst there is but little perceptible difference in the deflection, when a side wind is blowing, between it and the "heavy" pattern. Moreover, the maximum pressure and recoil are less with the "light" than with the "heavy" bullets, and the number of rounds that can be carried by the soldier is necessarily greater. Before proceeding to notice a few of the principal data, it should be stated that Messrs. Krnka and Hebler have taken out patents for their projectiles, and that their adaptation to existing rifles can be effected at a merely nominal cost, as the rifles only require resighting and a slight enlargement made in the chamber to allow for the base cup.

In the following tables V. represents remaining velocity in feet; B. 5.7, length of beaten zone in yards for an object 5 feet 7 inches high; B. 5.11, length of beaten zone for an object 5 feet 11 inches high; B. max. 5.7, maximum beaten zone for an object 5 feet 7 inches high; B. max. 5.11, maximum beaten zone for an object 5 feet 11 inches high; P., penetration in inches against dry deal; D., deflection in feet with side wind of 16½ feet velocity. Where

figures or words are given in parentheses, they refer to the normal data of the German Army rifle, 1888 pattern. The rifling, length, and diameter of shot and cartridge remain the same whatever type of bullet is referred to.

Ballistic data of the perfected "heavy" tubular bullet fired from the German rifle, 1888 *pattern.*—Length of bullet, 32 mm. (same); length of ogival head, 18 mm.; diameter, 8 mm. to 3.2 mm.; diameter of channel, 3.2 mm., with funnel opening out to 5.6 mm.; length of rear ogival, 12 mm.; diameter of rear ogival, 8 mm. to 5.6 mm.; weight of bullet, 10.8 grammes (14.5 grammes); weight of base cup, .3 gramme; powder charge, 2.75 grammes (same); initial velocity, $2362\frac{1}{4}$ f. s. (2100 f. s.); recoil, 1.20 m.kg. (1.54 m.kg.); length of cartridge, 82.5 mm. (the same); weight of cartridge, 24.45 grammes (27.5 grammes); number of cartridges weighing 8 lb. 13 ozs. = 164 (145); maximum pressure, 2200 atmospheres (3300); B. max. 5.7 = 803 yards (479 yards); B. max. 5.11 = 831 yards (492 yards); ballistic goodness of the rifle and ammunition, 1873 (474).

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. 5.7. Yards.	B. 5.11. Yards.	P. Inches.	D. Feet.
0	2362	.....	.....	41	.0
547	2165	.....	.....	39	.72
1094	1988	199	210	35	3.1
1640	1824	127	134	30	7.71
2187	1673	88	94	25	15.
2734	1535	65	70	21	25.66

The following are additional particulars: Effective range, 4814 yards; time of flight, 9.16 seconds; remaining velocity, 1105 f. s.; penetration against deal, 11 inches; maximum range, 8859 yards; effective range fired straight up in the air, 2953 yards.

Ballistic data of the perfected "light" tubular bullet fired from the German rifle, 1888 *pattern.*—Envelope of bullet filled with zinc, or with an alloy of zinc and tin. The dimensions of this bullet are the same as those of the "heavy" tubular bullet; its weight is, however, only 7.8 grammes, making the total weight of cartridge, complete, 21.45 grammes; the weight of 186 cartridges, therefore,

equals that of 145 of the ordinary German pattern, viz., 8 lbs. 13 ozs. With this bullet the maximum pressure is 1450 atmospheres; B. max. $5.7 = 870$ yards; B. max. $5.11 = 886$ yards; and the ballistic goodness of the rifle and ammunition 2240 as compared with 450 when the ordinary service bullet is fired from the same rifle.

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. 5.7. Yards.	B. 5.11. Yards.	P. Inches.	D. Feet.
0	2657	.....	.....	30¾	.....
547	2359	.....	.....	30	.82
1094	2093	215	238	27	3.6
1640	1857	136	144	22½	9.35
2187	1647	92	97	17¾	18.89
2734	1463	64	68	13¾	33.46

The following are additional particulars: Effective range, 4840 yards; time of flight, 9.71 seconds; remaining velocity, 922 f. s.; penetration against deal, 5½ inches; maximum range, 8226 yards; effective range fired straight up in the air, 2739 yards.

II.

In our previous article we gave the ballistic data of the perfected "heavy" and "light" tubular bullets fired from the German service rifle. We now give the data for these bullets from the 5 mm. Hebler rifle. The figures in parentheses refer to data for the ordinary bullet.

Ballistic data of the perfected 5 *mm. "heavy" tubular bullet.*—Length of bullet, 30 mm.; length of ogival head, 17 mm.; diameter, 5.1 mm. to 2 mm.; diameter of central channel, 2 mm., with funnel opening out to 3.6 mm.; length of rear ogival, 11 mm.; diameter of rear ogival, 5.1 mm. to 3.6 mm.; weight of bullet, 4.3 grammes; weight of base cup, .12 gramme (material, hard lead with steel jacket, and central channel lined with steel); powder charge, 1.5 gramme of Köln-Rottweil prismatic smokeless powder, with cartridge filled to the extent only of nine-tenths of its capacity; initial velocity, 2966 f. s., as compared with 2615 f. s. with the ordinary 5 mm. solid bullet; weight of rifle, 8 lbs. 13 ozs.; recoil, 0.72 m.kg.; length of

cartridge with bullet, 72 mm. (2.83 in.); weight, 13.3 grammes; number of cartridges weighing 8 lbs. 13 ozs, 301 (276); maximum pressure, 2460 atmospheres (3633); B. max. 5.7 = 1024 yards (564 yards); B. max. 5.11 = 1058 yards (575 yards). Ballistic goodness of the rifle and ammunition, 5213 (1429).

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. 5.7. Yards.	B. 5.11. Yards.	P. Inches.	D. Feet.
0	2966	.....	.....	33.14	.0
547	2769	.....	.....	34.45	.69
1094	2585	330	350	34.78	2.88
1640	2417	218	232	34.12	6.98
2187	2257	159	169	33.14	13.35
2734	2106	121	128	30.84	22.44

The following are additional particulars: Effective range, 5905 yards; time of flight, 8.84 seconds; remaining velocity, 1417 f. s.; penetration against deal, 17.67 inches; maximum range, 10,937 yards; effective range fired straight up in the air, 3644 yards.

Ballistic data of the perfected 5 mm. "light" tubular bullet.—Dimensions same as for "heavy" tubular bullet. The figures in parentheses refer to data for the 5 mm. solid bullet: weight of bullet, 3.1 grammes (5.8); material, zinc or an alloy of zinc and tin, with jacket and lining of central channel of steel; powder charge same as for "heavy" tubular bullet (1.5 gramme), but size of powder grains = .53 mm. instead of .72 mm.; length of cartridge, 72 mm.; weight, 12.1 grammes (14.5); number of cartridges weighing 8 lbs. 13 ozs. = 331 (276); initial velocity, 3340 f. s. (2615); recoil, .62 m.kg. (.80); maximum pressure, 1586 atmospheres (3633); B. max. 5.7 = 1113 yards (564 yards); B. max. 5.11 = 1144 yards (575 yards). Ballistic goodness of the rifle and ammunition, 5652 (1429).

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. 5.7. Yards.	B. 5.11. Yards.	P. Inches.	D. Feet.
0	3340	.....	.....	26.38	.0
547	3035	.....	.....	28.35	.75
1094	2762	372	394	29.53	3.34
1640	2510	223	247	29.92	8.33
2187	2283	163	173	28.74	16.37
2734	2077	119	125	26.38	28.3

The following are additional particulars: Effective range, 5957 yards; time of flight, 9.38 seconds; remaining velocity, 1187 f. s.; penetration against deal, 8.97 inches; maximum range, 10,180 yards; effective range fired straight up in the air, 3393 yards.

In the first two series the powder charge of 1.5 gramme only filled the cartridge case to the extent of nine-tenths of its capacity. The following data refer to the 5 mm. "light" tubular bullet fired with a full powder charge of 1.64 gramme of Köln-Rottweil prismatic smokeless powder, each facet being of the dimensions of .59 mm., so as to ensure perfect combustion. Where not otherwise specified the details are the same as before, and the figures in parentheses refer to the 5 mm. solid bullet. Weight of cartridge, 12.3 grammes (14.5); number cartridges weighing 8 lbs. 13 ozs. = 326 (276); initial velocity, 3546 f. s. (2615); maximum pressure, 2242 atmospheres (3633); B. max. 5.7 = 1157 yards (564); B. max. 5.11 = 1118 yards (575). Ballistic goodness of the rifle and ammunition, 5842 (1429).

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. 5.7. Yards.	B. 5.11. Yards.	P. Inches.	D. Feet.
0	3546	.....	.....	24.8	.0
547	2225	.....	.....	27.16	.69
1094	2933	414	438	29.13	2.98
1640	2667	258	273	29.92	7.38
2187	2428	180	191	29.53	14.5
2734	2208	132	140	27.95	25.5

The following are additional particulars: Effective range, 6299 yards; time of flight, 9.67 seconds; remaining velocity, 1187 f. s.; penetration against deal, 8.97 inches; maximum range, 10,617 yards; effective range fired straight up in the air, 3539 yards.

III.

In order to appreciate with greater readiness the advantages offered by tubular bullets and to compare their action more easily with the solid bullet at present in use in European armies, Professor Hebler gives the tables of the ballistic data of the 11 mm. German rifle, 1871 pattern, and of the 7.9 mm. rifle, 1888 pattern, the former

of which may be taken as fairly representative of the old class military weapon, and the latter as the representative of the modern small-bore rifle.

The following are the principal data applicable to the 11 mm. rifle (.433 inch): Weight of rifle, 9.92 lbs.; weight of bullet, 25 grammes; powder charge, 5 grammes; weight of cartridge, 42.8 grammes; number of cartridges weighing 8 lbs. 13 ozs. = 93; initial velocity, 1443 feet; maximum pressure, 1600 atmospheres; recoil, 1.58 m.kg.; B. max. 5.7 = 365 yards; B. max. 5.11 = 370 yards. Ballistic goodness of the rifle and ammunition, 100.

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. max. 5.7. Yards.	B. max. 5.11. Yards.	P. Inches.	D. Feet.
0	1443	.....	.....	9.5	.....
547	837	67	70	7.87	1.7
1094	590	21	22	4.33	10.89
1640	453	9½	10	2.36	35.76
1750	433	8	8¾	2.16	43.63

The following are additional particulars: Effective range, 1751 yards; time of flight, 7.86 seconds; remaining velocity, 433 f. s.; penetration against deal, 2⅙ inches; maximum range, 3227 yards; effective range fired straight up in the air, 1075.

The principal data of the present German rifle, 7.9 mm. bore (.311 inch), 1888 pattern, are as follows: Weight of rifle, 8 lbs. 6 ozs.; powder charge, 2.75 grammes smokeless powder; weight of bullet, 14.5 grammes (material, hard lead with steel jacket); weight of cartridge, 27.5 grammes; number cartridges weighing 8 lbs. 13 ozs. = 145; initial velocity, 2100 f. s.; maximum pressure, 3300 atmospheres; recoil, 1.54 m.kg.; B. max. 5.7 = 479 yards; B. max. 5.11 = 492 yards.

The ballistic data for the various distances are as follows:

Distance. Yards.	V. f. s. Feet.	B. 5.7. Yards.	B. 5.11. Yards.	P. Inches.	D. Feet.
0	2110	.....	.....	.....	.....
547	1188	126	133	16.93	1.24
1094	830	44	46	8.27	8.23
1640	636	20¾	21¾	4.72	27.46
2187	515	11½	12½	3.23	67.91
2734	433	7½	8	2.28	140.42

The following are additional particulars: Effective range, 2326 yards; time of flight, 8.74 seconds; remaining velocity, 492 f. s.; penetration against deal, 2.91 inches; maximum range, 4173 yards; effective range fired straight up in the air, 1391 yards.

A comparison of the data given in this last table with those given in our first article of August 12, shows the enormous increased efficiency which can be obtained from existing rifles by the adoption of tubular bullets, whilst the same data, compared with those given in our second article, show what may be expected by the introduction of rifles of 5 mm. calibre (.197 inch), which are sure sooner or later to be adopted by all European armies.

Assuming the amount of resistance offered by the atmosphere to the ordinary German 7.9 mm. solid bullet to represent 1000, Professor Hebler calculates that the resistance can be reduced to the following by the mere adoption of improved forms of bullet fired from the same rifle, viz.:

(1) Resistance offered to solid bullet with ordinary ogival head and flat base = 1000.

(2) Resistance offered to solid bullet with best possible form of ogival head and flat base = 541.

(3) Resistance offered to solid bullet with best possible form of ogival head and ogival base = 216.

(4) Resistance offered to tubular bullet with the best possible form of ogival head and base = 89.

With the 5 mm. rifle, again taking 1000 as the resistance offered to the ordinary solid bullet, the figures for the four different kinds of bullets stand at (1) 1000, (2) 463, (3) 185, (4) 66. It will thus be seen that with the best possible form of projectile the resistance offered by the atmosphere is only one-eleventh or one-fifteenth of that to which the ordinary solid bullet is subjected.

THE BUONACCORSI AUTOMOBILE TORPEDO.

[*By permission from the Journal of the Royal United Service Institution.**]

It is tolerably well known, through various notices which have appeared principally in the daily papers, that a new fish torpedo has been constructed by Count Adolf von Buonaccorsi di Pistoja, and we must fulfil the wishes of many of our readers who take an interest in torpedo matters if we here enter into a description of the above torpedo as compiled from five letters patent and two printed pamphlets which have been laid before us. As can be perceived from the whole tenor of the following description, we confine ourselves strictly to the employment of the above printed notices without giving any opinion whatever on the torpedo itself, its mechanism, or the qualities ascribed to it, etc. The Buonaccorsi torpedo is propelled by the reaction due to the efflux of compressed air from the blades of the propellers. This invention, as well as the special mechanism for controlling the depth, sinking the torpedo at the end of its run, exploding the charge, and also the charging and supply valves, are subjects of the letters patent above mentioned. Trials with the Buonaccorsi torpedo were carried out, to our knowledge, in 1890, at the Imperial launching station in Kiel, and further in Nussdorf, near Vienna; the results, however, have not yet been published. The fact that the "Vulcan" Company, in Stettin, has acquired the patent in Germany for this torpedo, and has established a range with a view of carrying out extensive experiments with it, proves at any rate that with them the invention is considered of the highest importance. Buonaccorsi endeavors in his torpedo to overcome the defects which, in spite of all improvements, and the great perfection of the present type, still remain in the Whitehead torpedo,

*Translated by T. J. Haddy, R. N., from the *Mittheilungen aus dem Gebiete des Seewesens.*

viz.: (1) complexity, as a result of which constant accidents occur in the propelling, balancing, and depth-controlling mechanism; (2) limited range, by means of holding a high velocity of the torpedo in reserve. In external form the Buonaccorsi is exactly similar to the Whitehead, with pistol, charge, depth-regulator, air reservoir, rudders, and twin screws. (Fig. 1.)

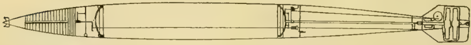


FIG. 1.

The following description of the internal mechanism, as already mentioned, is exclusively from the letters patent: Propelling mechanism of the Buonaccorsi torpedo. Up to the present, the propulsion of automobile fish torpedoes in general is obtained by the action of compressed air on the piston in an engine cylinder, producing the rotation of the propeller shafts, and by means of gearing the revolution of two propellers in opposite directions. This kind of propulsion is subject to the following losses of power: The air pressure during admission to the cylinder, and also on exhaust after having performed its work there, has to overcome considerable resistance during its passage, and the friction of machinery and the continual change of direction in motion of the pistons and slides of the engine cause continual loss of power. The necessity of a regulator to maintain a constant pressure, and speed of engine and torpedo during the period of its run, also causes a waste of power, and finally the wheel gearing employed to obtain the rotation of the propellers in contrary directions also requires an expenditure of power. By all these conditions the scope of the motive agent is decidedly contracted, and the obtainable speed of the whole mechanism brought into narrow limits. The system of propulsion of Count Buonaccorsi permits that the cylinder-engine, pressure regulator, and wheel gearing may be dispensed with, with the possibility of simplifying the mechanism of the torpedo considerably, and also increasing the useful work obtained from the compressed air. The principle of this system consists in developing the energy, by applying the reactive force of compressed air, allowing it to escape freely, immediately to the propellers and

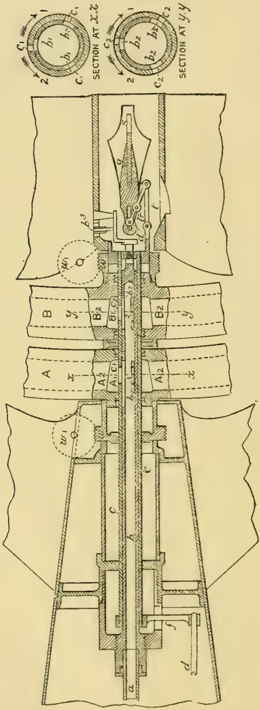
causing them to revolve, instead of employing the statical pressure of the air on a piston when confined in the cylinder of an engine.

Of the annexed figures, Fig. 2 shows a longitudinal section of the after part of the torpedo with both propellers; Fig. 3 and Fig. 4, sections through $x—x$ and $y—y$ of Fig. 2. The air, which is compressed to 70 or 90 atmos. into a cylindrical reservoir slightly smaller in diameter at both ends, is led out of the reservoir through a fixed tube, *a*, which is connected by an air-tight connection with another tube, *b*, the latter capable of revolution on its axis, and enclosed by the tube *c*; on these tubes the propellers *A* and *B* are fitted, of which *A* is a right-handed, and *B* a left-handed screw. The boss of each of these propellers contains a conical chamber A' and B', which surrounds the tube *c*, and into which the compressed air has access through the tubular shafts *b* and *c*, and the slits b', c', and b^2, c^2, which are cut through them. The air is led out of these chambers (which form a sort of pressure reservoir, and by means of which, in conjunction with the propellers, which act as governors, the speed of the torpedo can be regulated) through the channels A^2, A^2, B^2, B^2 formed in the blades of the propellers, to the surrounding atmosphere or water, as the case may be; and the rotation of the propellers in the opposite direction to the issuing air is thus obtained by the force of reaction. The speed of revolution of the two propellers is regulated by the size of the openings through which the compressed air is admitted to the chambers *A* and *B*, and the speed of the propellers may be quite different, as by this means the unequal effect of the propellers, which up to now has had to be counteracted by means of rudders, etc., is obliterated, and the adjustment of the torpedo effected; the inventor has found by experience that, with the increase or decrease of the speed of propeller, its directive effect on the torpedo increases or decreases, and consequently it is only necessary to make the difference in speed of the propellers of such a magnitude as to exactly balance each other in directive effect on the torpedo.

Again, as before mentioned, the speed of the propellers depends on the size of the openings through the two tubes *b* and *c*, through which the air pressure is admitted to the chambers A' and B'; it follows, therefore, that by changing the size of these openings, changes in the revolutions of the propellers, independently of each other, may be obtained, and consequently a resultant steering effect

FIG. 3. FIG. 4.

FIG. 2.



on the torpedo. The variations in the size of these air supply orifices is obtained in the following manner: The inner tube *b*, Fig. 2, side view and section, is provided with the longitudinal slits b^1 and b^2, Figs. 3 and 4, in section, in the wake of the propellers, and these openings communicate with similar openings of half the width in the outer tube, *c*, and it can be so arranged that the compressed air may be admitted to the chambers *A* and *B*, through the full area of the openings c^1 and c^2, or these areas can be reduced by altering the relative positions of the inner and outer passages. The two openings c^1 and c^2 can never come at the same time in coincidence with their corresponding openings b^1 and b^2 in tube *b*, and it is by revolving the pointer b^3 fixed to the tube *b*, in direction of the arrow 1 (Figs. 3 and 4), that it is possible to throttle the air admitted to propeller *A*; or *vice versa*, by moving the pointer *b* in direction of arrow 2.

For registering the number of revolutions of the propellers throughout the run, the two worm wheels *w*, and the toothed wheels *w'* (Fig. 2) are fitted. In this after part of the torpedo there is also a part of the depth-steering apparatus, viz., Fig. 2, the diving rod *d* worked by the steering engine, and connected rigidly to the tube *c* by the arm *f*, so that, as the latter tube is movable in an axial direction to the tube *b*, the movement of the arm *d* can be transmitted without change to the rod *d'*, in the after end of the tube *c*. This rod *d'*, by means of the connecting rod and lever, *t*, *t*, is connected to the horizontal rudders and communicates to them directly the movements of the diving rod. The most important novelties claimed by the inventor in his patent are: (1) the propulsion by means of the reaction of compressed air on the propeller blades; (2) the means of governing the direction of the torpedo by variation of speed of the propellers through varying the supply of air pressure to the same; (3) the mode of transmitting the movement of the depth regulator to the horizontal rudder arms by means of the hollow movable propeller shafts.

With regard to the construction and dimensions of the new propelling apparatus, the following calculated results are taken from an article by the inventor. The air is compressed to 80 atmos. into a reservoir of a capacity of about 0.12 cub. m. $= 4\frac{1}{4}$ cub. ft. This air flows through a straight tube of the same effective area as the outlet orifice in the reservoir by the shortest course to the hollow

tubes of the propeller shafts. On these shafts, in the usual position, not keyed on but movable on their shafts, are the two-bladed propellers of 0.32 m. diameter ($12\frac{5}{8}$ in.). The boss of each propeller contains the conical air chamber already described, and each is fitted air-tight, both at its forward and after sides. The air pressure passes out from the before-mentioned conical chambers by four channels of rectangular section, 30 mm. by 1 mm. in width, into an outlet opening of 0.00003 sq. m. in area, bored through each of the propeller blades, leading out to the point of the blade. The radius of curvature of these channels is constant, and equal to 0.1 m. The angle at which the concave surface of the channel is met by the issuing air is 10°, the bend of the channel is 90°, the whole length of the surface acted on by the pressure in each channel is therefore 0.15 m. By the calculation of the inventor, his propelling mechanism, with an initial pressure in reservoir of 80 atmos., and using up all the energy of the air to the final pressure of 20 atmos., obtains a useful effect of 109e (= H. P.), which gives the torpedo a velocity of 34 knots, or in two minutes it would cover a distance of 2000 m. The charging and air-supply valves of the Buonaccorsi torpedo have, in the view of the inventor, particular advantages: whilst in the other fish torpedoes worked by compressed air the air supply valve is a lift valve, in the Buonaccorsi a cock is used, and the plug is held in position by a flat spring, which bears against a square on the plug both in the "open" and "closed" positions. The key which opens and shuts this cock is connected to one arm of a three-armed lever, the other arm of which projects through the shell of the torpedo, and serves to open the cock in the same way as the air lever of the Whitehead torpedo, that is, by means of the tripper of the launching tube. The automatic closing of the starting valve is obtained by the action of the propelling mechanism on wheel work which releases a spring which has been put into compression on opening the starting valve, and which is connected by means of a link to the third arm of the lever on the plug of air cock. The charging pipe is fitted directly on the after end of the air reservoir, immediately in front of the air supply valve and connected to the same pipe, the valve itself being fitted on the upper end of the charging pipe, so that when it is compressed by the charging nozzle a direct communication is opened up to the air reservoir. The depth-controlling apparatus is on the same prin-

ciple as in the Whitehead torpedo, a combination of a hydrostatic valve and spiral spring and heavy pendulum, the spring adjustable to the pressure corresponding to the required depth of the torpedo during its run. This apparatus is placed immediately in rear of the explosive chamber, and the action is communicated to a servo-motor by a rod passing through a tube through the air reservoir. There is also an arrangement for fixing the horizontal rudders in any desired position for a certain time, and for bringing the rudders up when the torpedo is stopped, and so bringing it to the surface. A sinking valve can also be opened at the same time, if desired, to sink the torpedo by admitting water to the after chamber. The safety pistol, to prevent a premature explosion of the charge, is of the "fan" pattern. The material of which the torpedo is constructed is, with the exception of the steel air chamber, Austrian delta metal.

From a pamphlet by the inventor, it appears that it is proposed to make the air chamber also of delta metal, the experiments on a shortened air vessel of this metal having shown that there would be no technical difficulty. The inventor claims for his "reaction" torpedo, as against the automobile fish torpedo: 1, increased speed; 2, increased range; 3, greater reliability in direction; 4, simpler mechanism; 5, more perfect action of the steering apparatus; 6, increased range of depth, as well as a simpler and more certain adjustment of the same; 7, larger range of action of the explosive; 8, more exact adjustment of the controlling gear of horizontal rudders; 9, more reliable action of the stopping and sinking gear.

Further, the fish torpedoes of former types may with comparatively small expense be easily converted into the Buonaccorsi type, as the explosive chamber, air chamber, buoyancy and balance chambers, etc., are not interfered with to any great extent by the new fittings, and a good many of the internal parts also may be utilized in the conversion.

PROFESSIONAL NOTES.

CALIBER OF THE NEW NAVY RIFLE.

On the 31st of last July, a Board, consisting of Commander G. A. Converse, U. S. Navy, Captain George C. Reid, U. S. Marine Corps, Professor Philip R. Alger, U. S. Navy, and Ensign A. C. Dieffenbach, U. S. Navy, was appointed by the Department "for the purpose of considering and deciding upon the caliber of rifle to be used in the naval service and to test and select the rifle best suited to that service." The first question considered, that of the caliber, was reported on August 22, the Board deciding upon 6 mm. (.236 in.). Their report reads as follows, and is published by permission of the Bureau of Ordnance.

The history of the development of small-arms shows a constant decrease of caliber, accompanied by an increase of ballistic qualities; and the rapid advance of technical science, with resulting improvements in the material and methods of manufacture of modern arms and ammunition, has in recent years given impetus to this movement.

The calibers, from 0.40 in. to 0.45 in., generally adopted with breech-loading, began to be succeeded by smaller calibers in the years from 1886 onwards, and to-day almost every civilized nation uses a rifle of or below 8 mm. (0.315 in.) in caliber. With these small caliber rifles the charge is smokeless powder; the muzzle velocity 2000 f. s. or over; the point blank range about 400 meters; the effective range upwards of 2000 meters, and the number of rounds carried per man 100 or more.

The arm now in use in the U. S. Navy is of 0.45 in. caliber; the charge is black powder; the muzzle velocity 1350 f. s.; the sights must be adjusted for ranges above 150 yards; the effective range is 1200 yards, and only 55 rounds are carried per man.

This progressive reduction of caliber, still going on, as evidenced by the recent adoption of the 6.5 mm. rifle by Italy, Roumania and Holland, and of the 7 mm. rifle by Spain and Chili, together with the manifest superiority of the smaller calibers, leads the Board to the conclusion that a change of caliber for the navy small-arm is desirable, and that this change should be a reduction.

For the naval service the small-arm has two principal uses—in picking off or driving under cover the exposed men of opposing boats or ships, and on landing expeditions.

For the former use great flatness of trajectory and penetrating power are desirable, distances being usually considerable and uncertain; the weight of the ammunition is unimportant, since the source of supply, the ship's magazine, is close at hand; and the feature of exchangeability with ammunition used by others is valueless.

On landing expeditions, lightness of ammunition, allowing a large number of rounds to be carried, is of great importance, especially in the probable case of the landing being in a savage country where transportation, excepting on the person, is difficult or impossible. But here, also, the use of the same ammunition as others can only be desirable where a combined expedition of naval and other forces is undertaken, and such

cases will rarely occur, since the weight of authority is against the use of naval forces in prolonged or distant land service, and since in any case where it became necessary to land a military force the naval force could probably be best employed in keeping open communications and as a base of supplies, ammunition being furnished from transports and store ships specially fitted out for the expedition. The usual duties of naval landing parties are likely to be only such as protecting property and putting down mobs in sea coast cities, and in necessary attacks upon savage or semi-civilized people in their own countries, in either case the expedition being purely naval and of limited extent and duration—and for such duties interchangeability of ammunition would be of no importance.

Considering, then, that on the actual field of war the ballistic and tactical qualities of the navy small-arm are far more important than that its ammunition should be the same as used by the army, it remains to determine the advantages of the latter feature in manufacture and supply at home. Small arm ammunition for the army is now made at the Frankfort Arsenal, while that for the navy is made in private factories. In time of war it would be necessary to employ all the resources of the Government and private factories in the manufacture of ammunition, and it does not appear either that the expense would be greater or that any complications could arise from the use of different ammunition by the two services.

Consequently the Board concludes that the advantages which would result from the use of a common ammunition by the U. S. Army and Navy are not sufficient to warrant any considerable sacrifice of ballistic or tactical qualities.

It becomes, then, a question whether there is any small-arm of different caliber from that adopted by the U. S. Army which possesses materially superior ballistic or tactical qualities, and an examination of the records of tests of arms recently adopted or experimented with abroad shows that there are such arms, and the Board concludes that their superiority results from their smaller calibers.

The following table gives the data of the U. S. Army 0.30 in. cal. and the Mannlicher 6.5 mm. (0.256 in.) rifles:

	U. S. Navy.	Mannlicher.
Caliber	0.300 in.	0.256 in.
Weight of gun without bayonet	8.75 lbs.	8.46 lbs.
Length of barrel	30.00 in.	28.75 in.
Weight of bullet	220 grains.	162 grains.
Weight of round complete	410 grains.	338 grains.
Muzzle velocity	2000 f. s.	2390 f. s.

The sectional density of the 6.5 mm. bullet being the same as that of the 0.30 in. cal., its carrying power is the same, and, having a vastly greater initial velocity, its trajectory is flatter and its terminal velocity is greater at all ranges. The penetration of the smaller bullet is also the greater, at least at effective ranges. Moreover, the 6.5 mm. ammunition being the lighter, one-fourth more rounds of it can be carried with equal total weights. Finally, the shock of recoil is less with the smaller caliber, notwithstanding its greater muzzle velocity.

The following are some of the results obtained with the 6.5 mm. Mannlicher rifle in actual tests.

Range.	Penetration.
15 yards.	27.2 in. beech blocks.
50 "	49.0 in. pine wood.
330 "	32.6 in. packed earth.
2730 "	4.4 in. pine wood.

Angle of Elevation.	Range.	Angle of Fall.	Remaining Velocity.
0° 04′ 00″	109 yds.	0° 04′ 50″	2132 f. s.
0° 25′ 10″	545 "	0° 34′ 40″	1460 "
1° 11′ 30″	1093 "	1° 51′ 20″	1082 "
5° 23′ 20″	2186 "	9° 39′ 20″	663 "
9° 16′ 00″	2731 "	16° 50′ 30″	571 "

TRAJECTORY FOR 491 YARDS RANGE.

Distance, 83 yds.	165 yds.	247 yds.	288 yds.	328 yds.	409 yds.	491 yds.
Height, 17 in.	28 in.	32 in.	33 in.	31 in.	20 in.	0 in.

Height of Rifle.	Height of Target.	Danger Space.
4.9 ft. (standing).	5.9 ft. (infantry).	550 yds.
" " "	8.9 " (cavalry).	710 "
1.3 " (reclining).	5.9 " (infantry).	660 "
" " "	8.9 " (cavalry).	790 "

For comparison with the above the following are some results obtained with the 8 mm. rifle having an initial velocity of 2034 f. s. Penetration in beech blocks at 15 yards from muzzle, 20.8 in., against 27.2 in. for the 6.5 mm.; danger space, fired standing against infantry, 450 yards, or 100 yards less than for the 6.5 mm.; greatest height of 660-yard trajectory, 9.4 ft. against 5.4 ft. for the 6.5 mm.

The great superiority of the 6.5 mm. rifle over the larger calibers from a ballistic and tactical point of view is apparent, and explains the fact that this caliber, or the 7 mm., has been the choice of every nation which has recently adopted a new arm. Moreover, even those countries which have rearmed with the 7.5 to 8 mm. calibers have carried on, or are now engaged in, extensive tests with the smaller calibers, and appear to be only deterred from adopting them by the enormous expense of a second re-arming.

As an example of the trend of opinion abroad, it may be stated that only one gun of a caliber above 7 mm. was brought before the Commission which, in November and December, 1892, tested arms for adoption by Chili, and all, excepting this gun, gave initial velocities of 2400 f. s. or over.

Furthermore, while as yet no nation has adopted a less caliber than 6.5 mm., extensive tests with 6 mm., 5.5 mm., and 5 mm. rifles have been carried on, and several high authorities advocate the immediate adoption of the smallest of these.

The superior qualities, both ballistic and tactical, which theory indicates as the result of a decrease of caliber, having now been confirmed by practical tests and demonstrated beyond doubt for calibers as low as 6.5 mm., it is necessary to examine the reasons for fixing a limit to this reduction of caliber and to determine this limit.

First, there are difficulties of manufacture which have constantly retarded the movement of reduction of caliber, but which have gradually been overcome, until with modern processes 5 mm. guns can be, and have been constructed. Increased cost of arms and ammunition accompanies any reduction of caliber, but it becomes considerable only when the minimum caliber is approached.

Next is the difficulty that with the increased velocities and twist of rifling accompanying the smaller calibers, the strains are also greatly increased; but improvements in the quality of steel used for barrels, and the greater strength and security of modern breech mechanisms enable these strains to be safely withstood, and prevent the rapid wear of the barrel which results from the use of inferior material. The use of jacketed bullets without lubricant, and of powder with little or no residue, together with the ease with which modern breech bolts can be removed, tend to

prolong the life of small caliber arms and to render their care and preservation in service entirely practicable.

Last is the objection to the small calibers that the wounds produced by them will frequently not be sufficient to immediately put the wounded out of action, and that their shock will not stop the onset of excited men at short range. In reply to this it may be said that reports of the effect of modern arms of about 8 mm. caliber in actual warfare all point to the efficiency of these arms; that experience with the smaller calibers has been limited to experiments whose results are contradictory; and that this objection holds nearly equally for all modern rifles. Therefore the Board concludes that this doubtful and unproved disadvantage should not be allowed to outweigh the many certain and proven advantages of the very small calibers.

The two great arguments in favor of the smaller calibers are their higher ballistic qualities and the decreased weight of their ammunition, but neither of these advantages is proportional to the decrease of caliber, since the weight of charge and cartridge case must be kept up in order to increase the velocity as the caliber decreases. Consequently the reduction in the weight of ammunition as the caliber is reduced from 6 mm. to 5 mm. will be extremely small, if the velocity is maintained or increased, and since the 5 mm. is the smallest caliber that has yet been manufactured, and since its efficiency depends upon a choice of the finest material and the most accurate workmanship, involving a very considerable increase of expense, it would appear that in the present state of the art a reduction of caliber below 6 mm. is not advisable. As a means of reducing cost the Board recommends the adoption of the millimetre as the unit since the possibility of manufacturing arms for foreign nations or disposing of the machinery after the completion of the necessarily small order for the Navy, would tend to promote competition.

Therefore, after a careful consideration of the foregoing facts and arguments, and after having satisfied itself by personal interviews with manufacturers that arms and ammunition of 6 mm. caliber can be made without special difficulty, the Board concludes that a small arm of 6 mm. caliber should be adopted for the U. S. Naval Service, and an arm with the following principal characteristics is recommended:—

Caliber	6 mm. (0.236 inches).
Weight of bullet	about 135 grains.
Weight of charge	" 33 "
Capacity of case	35 grains.
Pitch of rifling	1 turn in 6.5 inches.
Number of grooves	6
Depth of grooves	about 0.003 in.

From computation based upon results obtained with the Troisdorf powder in the 0.30 in. cal. rifle, the Board believes that with the proposed arm a muzzle velocity of 2400 f. s. can be attained with a maximum pressure less than 50,000 lbs. per square inch.

In this recommendation due consideration has been given to the desirability of using the same ammunition for machine guns as for the small arm, and the Board deems that no difficulty in the manufacture or manipulation of machine guns will be caused by their use of 6 mm. ammunition.

The following tables give the comparative data of the proposed 6 mm. and the U. S. Army .30 cal. rifles, both being computed, from which it will be seen that with the 6 mm. rifle the trajectory is flatter, the remaining velocity greater, and the shock of recoil less than with the 0.30 in. rifle, while one-third more rounds of ammunition can be carried with an equal weight.

TRAJECTORIES—500 YARDS.

Caliber	.30 inch.	6 mm. (0.″236).
Muzzle velocity	2000 f. s.	2400 f. s.
Terminal velocity	1134 f. s.	1331 f. s.
Angle of elevation	0° 32′ 00″	0° 22′ 15″
Angle of fall	0° 46′ 54″	0° 32′ 48″
Height of vertex	4.23 feet.	2.95 feet.
Distance of vertex	274 yards.	275 yards.
Time of flight	0.97 sec.	0.85 sec.
Danger space for 6 feet	500 yards.	500 yards.
Proportional deviations due to side wind	1.02	1.00
Energy of recoil	10.9 ft. lbs.	7.2 ft. lbs.

1000 YARDS.

Caliber	.30 inch.	6 mm. (0.″236).
Muzzle velocity	2000 f. s.	2400 f. s.
Terminal velocity	853 f. s.	923 f. s.
Angle of elevation	1° 36′ 25″	1° 10′ 50″
Angle of fall	2° 41′ 42″	2° 10′ 08″
Height of vertex	28.57 feet.	21.70 feet.
Distance of vertex	564 yards.	576 yards.
Time of flight	2.39 sec.	2.25 sec.
Danger space for 6 feet	132 feet.	166 feet.
Proportional deviations due to side wind	0.89	1.00

THE NEW GUNBOATS.

[*Journal of the American Society of Naval Engineers.*]

GUNBOAT NO. 7.—At its last session Congress authorized the construction of three light-draught gunboats adapted to river service. It was the intention, at first, to have the hulls of two of them composite and sheathed, and designs had been prepared with that idea, but, as the Act of Congress said "steel gunboats," an opinion was requested from the Attorney-General, who decided that they must be of steel. It seems somewhat ludicrous that the unanimous opinion of the Navy Department as to what was best in the design of ships should have to yield to a literal interpretation of an act doubtless framed hurriedly and probably without any intention of hampering the Department's action. The importance of sheathing our ships which are to make long cruises on foreign stations is undoubted, and has been repeatedly urged by Chief Constructor Hichborn. It is worth noting, too, that many foreign vessels of great size are now building which are to be sheathed.

Gunboat No. 7, while of light draught, is still of what may be called ordinary design, the constructors having reasonable latitude in the work. As will be noticed later this is not the case with the other two vessels.

The principal hull dimensions of No. 7 are:

Length over all	233 feet 9 inches.
Length on L. W. L.	220 feet.
Beam at L. W. L.	36 feet.
Mean draught	11 feet.
Displacement	1,260 tons.
Coefficient of fineness	.506
Freeboard forward	17 feet 11 inches.
Freeboard aft	16 feet 2 inches.

The speed developed by the vessel, under conditions to be prescribed by the Navy Department, must not be less than an average of 14 knots per hour, maintained successfully for four consecutive hours, during which period the air pressure shall not exceed in the ash pits of the return fire-tubular boilers a pressure of 1 inch of water, and in the ash pits of the tubulous boilers a pressure of 2 inches of water, and for speed developed and maintained above 14 knots an hour the contractors shall receive a premium at the rate of $20,000 per knot, while, if the speed falls below 14 knots, a penalty at the same rate will be exacted. If the average speed falls below 13 knots, the vessel will be rejected.

The hull is to be of steel, not sheathed, with double bottom and close water-tight subdivision at the water line. The water-tight subdivision is to be so arranged that at least two skins must be pierced to admit water to the engine or fire-rooms. The arrangements of decks above water are such as to provide ample freeboard and berthing accommodations.

There will be two military masts with light sail power. The boats must be stowed clear of the blast of the guns, but two life-boats must be so carried as to be rapidly lowered under all conditions of weather.

There will be a water-tight deck near the water line. Below this deck will be the propelling machinery, steering gear, magazines, shell rooms, and, in short, all the "vitals" of the vessel.

Protection of the hull against injury to the water-line region will be afforded by coal protection and suitable water-tight subdivision.

The battery will consist of eight 4-inch R. F. B. L. R., four 6-pounder R. F. Hotchkiss, two 1-pounder R F. Hotchkiss, two Gatlings. The 4-inch guns are to be mounted as follows: Four in the open on the spar deck, placed two forward and two aft, and four in sponsons on a covered gun deck, two on either broadside. The guns on the spar deck will be protected with shields attached to the gun carriages. Those on the gun deck will be protected by sponson armor 2¼ inches thick. Protection will be afforded the smaller guns by shields and extra side plating.

There will be one torpedo tube placed at the bow above the water line.

Evaporating and distilling apparatus will be fitted for fresh water supply; the allowance of water to be carried to be sufficient for fifteen days for officers and crew; and in addition sufficient to supply the boilers with fresh water for one day's steaming at full power (about 11 tons).

The total coal capacity will be 380 tons, of which 150 tons will be carried at normal displacement.

The electric lighting plant will consist of two units, each unit having an engine, dynamo and combination bed-plate, and each dynamo having a rated output of 100 amperes at 80 volts. The total weight of the whole electric installation, including all fittings, search lights, etc., will be about 10 tons.

Estimated Weights.

Hull fittings	705	tons.
Sponson armor	12	"
Armament, including ammunition, torpedo outfit, etc.	74	"
Main and auxiliary machinery	161	"
Fresh water for boilers	11	"
Equipment, outfit and stores	148	"
Coal at normal displacement	150	"
Total weight, equal to normal displacement	1,261	"

The following boats will be carried: one 30-foot steam cutter; one 30-foot sailing launch; two 28 foot cutters; two 29-foot whale boats; one 18-foot dinghy.

The vessel has a covered gun deck, and the cabin and wardroom are

on the after part of this deck, the wardroom country being T-shaped, with the table in the cross of the T athwartship; eight of the wardroom staterooms are on this deck, the other four being on the berth deck below. Just forward of the wardroom, but separated by a bulkhead, are the pantry and bath-rooms.

Just forward of this bulkhead is a space about 100 feet long for the battery, and berthing space for the crew. Forward of this space are the refrigerating room, petty officers' bath-room, crew's water-closet, etc.

On the berth deck, abaft the four wardroom staterooms, are the cabin and wardroom storerooms, while forward of the wardroom are apartments like those for junior officers on most ships, but which will be here for the petty officers. Instead of stationary bunks they will be fitted with berths like those on a Pullman sleeper.

The compartment just forward of this will be mainly taken up by engine and boiler hatches, but some of the crew will find berthing space. The next compartment will also be partly occupied by hatches, but will include coal bunkers, dynamo rooms and engineer's workshop. The remainder of the space on this deck will be for berthing the crew.

The hold, besides containing the machinery and coal bunkers, will have the magazines, store-rooms, etc.

The complement will consist of 11 officers, 129 sailors and firemen, and 10 marines, making a total of 150.

The engines will be twin-screw, vertical, inverted-cylinder, direct-acting, quadruple-expansion, with cylinders 11, 17, 24 and 34 inches diameter and a piston stroke of 18 inches; designed for 1,750 indicated horse-power with a piston speed of 900 feet.

The boilers are in two groups, the forward or main boilers being of the tubulous or sectional type and designed for a working pressure of 250 pounds; they contain about 100 square feet of grate and about 4,000 square feet of heating surface.

The after or auxiliary boilers are cylindrical return-tubular, two in number, and designed for a pressure of 160 pounds.

For full power steaming, the design is to run as a quadruple-expansion engine with steam from the main boilers to the high-pressure cylinder, steam from the auxiliary boilers going into the steam chest of the first intermediate cylinder. For steaming at low power, the engine is intended to run triple expansion, there being a disconnecting coupling by which the low-pressure cylinders can be thrown out, and exhaust pipes properly arranged to complete tbe design. The steam pipes of the two groups of boilers are so arranged that both may work at the same pressure (up to 160 pounds) on the main steam pipe to the high-pressure cylinders.

There is one condenser for each main engine, each with its own circulating pump, to which is attached a vertical auxiliary air pump, so that each condenser may be used in port for auxiliary purposes. The main air pumps are of the vertical-bucket type, one for each engine, each worked from the crosshead of the second intermediate cylinder.

The valves for the H. P. and first I. P. cylinders are of the piston type, and those for the second I. P. and the L. P. cylinders double-ported slides, all worked by Stephenson link-motion.

The framing consists of wrought-steel columns supported on cast-steel bed plates, which rest upon the inner bottom plating.

The cylindrical boilers are each 7 feet 8 inches diameter and 9 feet 10 inches long, each with one corrugated furnace flue, 40 inches internal diameter, the total grate surface of these boilers being 42 and the total heating surface 1,358 square feet. They have been designed with special reference to cleaning and scaling, as it is the intention to have one of these boilers in use at all times, and, if necessary, to use salt feed in them only. For all ordinary passages, the fresh-water tanks built in the ship will be

ample; but for long ones, it would be necessary to use the evaporator make-up and probably some salt feed, which, of course, must not be put in the tubulous boilers. The type of boilers and their size has been somewhat restricted in this vessel on account of her comparatively light draught, and from the fact that she has a double bottom.

Forced draft will be on the closed ash-pit system.

There are two main feed pumps in the engine-room and one in each fire-room, the latter, as well as the fire and bilge pump, being fitted to pump from the main drainage system, and all the pumps except the main feed as fire pumps.

There will be the usual evaporating, distilling and refrigerating machinery, turning engine, workshop engine, dynamo, ventilating, capstan and steering engines, ash hoist, and ash ejectors of the See pattern, the latter being the first to be fitted in any vessel of the navy.

The weight of machinery, including water, auxiliaries and spares, is 172 tons.

In some respects the machinery of this vessel is novel, and represents an original and admirable solution of the problem of making machinery that is amply powerful at top speed and economical at cruising speeds. Quapruple-expansion engines working with 250 pounds pressure certainly should give economy at full power, and it is to be noted that the three smaller cylinders have been specially arranged to be economical at a cruising speed of about 10 or 11 knots. It was for economy also that the air pumps are worked from the main engines, thus reducing the waste in this, the most powerful auxiliary.

The combination of the two sets of boilers at 250 and 160 pounds for full power is novel, but is really only an extension of the principle of exhausting the auxiliaries into the receivers.

In the same way the cylindrical boilers should be very efficient with a ratio of heating to grate surface of over 32. Under natural or light forced draft they should give a high economic evaporation.

It is probable that, when this vessel is completed, a series of extended tests will be made at various powers to determine just where the losses occur. At present the efficiency of the engine cannot, ordinarily, be separated from that of the boilers.

Gunboats 8 and 9.—These have been specially designed for river service, so that the draught is very limited. This has hampered the hull designers materially, so that, while the design is an admirable solution of the problem before them, the vessel cannot be expected to show as good a performance as if they had had greater freedom in the choice of dimensions.

The hull data are as follows:

Length over all	252 feet 0 inches.
Length on L. W. L.	250 feet 0 inches.
Beam at L. W. L.	40 feet 0 inches.
Mean draught	8 feet 10 inches.
Displacement	1,313 tons.
Coefficient of fineness	.517
Freeboard at bow	19 feet 2 inches.
Freeboard at stern	11 feet 2 inches.

The contract speed is 13 knots and the premiums and penalties are the same as for No. 7.

The provisions as to water-tight subdivision, etc., are the same in general as in No. 7, but there will be only one military mast.

The battery is the same as for No. 7, but the arrangement is different. Two of the 4-inch guns will be mounted on the forecastle and the remainder on the gun deck. Those in the open will be protected by

shields; the remainder by sponson armor 2¼ inches thick. The smaller guns will be protected by shields.

The total coal capacity will be 275 tons, of which 100 tons will be carried on the normal displacement.

The other matters are in general similar to those for No. 7, and the same complement of officers and crew will be carried.

ESTIMATED WEIGHTS.

Hull and fittings	771	tons.
Sponson armor	10	"
Armament, including guns, mounts and hoists	70	"
Equipment, outfit and stores	152	"
Coal at normal displacement	100	"
Main and auxiliary machinery	200	"
Fresh water for boilers	10	"
Total weight, equal to normal displacement	1,313	"

The boats carried will be the same as those for No. 7, except that the steam-cutter and sailing-launch will be 33 feet long.

The engines will be twin-screw, vertical, inverted-cylinder, direct-acting, triple-expansion, with cylinders 14½, 22 and 33¾ inches diameter, with a piston stroke of 18 inches; designed for 1,600 indicated horsepower, with a piston speed of 850 feet per minute and a boiler pressure of 180 pounds.

The valves are of the piston type for the high and intermediate, and double-ported slide for the low-pressure cylinders, all worked by Stephenson link-motion. The framing consists of wrought-steel columns supported on cast-steel bed plates, which rest directly upon the inner-bottom plating.

There is one main condenser common to both engines, and one main circulating pump, with connections for pumping from the main drainage system, the double bottom and the engine-room bilge. The main air-pumps are vertical bucket-pumps, one worked from each main engine. For use in port there is an auxiliary condenser, with a combined air and circulating pump large enough for all the auxiliary machinery that might be in use at any time.

For the same reasons that obtained in Gunboat No. 7 the choice of boilers was restricted, and as these vessels are intended for use in China waters it was decided to put in boilers which could, if necessary, be fed with salt water and which could be readily scaled. Six return-tubular boilers of the same size as those designed for No. 7 will be fitted. They will be placed in two water-tight compartments, but with only one smoke pipe, and will contain 120 square feet of grate and 4074 square feet of heating surface.

Forced draft will be on the closed fire-room system.

The same system of feeding and pumping is adopted as in No. 7, and the same auxiliary machinery is fitted.

The weight of machinery, including auxiliaries, water and spares, is 200 tons, which seems heavy for modern machinery. This is due to the boilers. As already stated, owing to the peculiar service for which these boats are intended, it was not considered advisable to fit tubulous boilers. Owing to the very limited draught and to the double bottom, the greatest diameter permissible for cylindrical boilers is 7 feet 8 inches, which compelled the use of six boilers.

As in the case of the hull, the design is an excellent solution of the problem before the designers, but, unless the limitations of the case are borne in mind, it may seem that the results are not quite up to the best recent practice.

LIEUT. FISKE'S DEPRESSION POSITION FINDER.

[By permission from the *Electrical Engineer*, June 21, 1893.]

We have already described several arrangements devised by Lieut. B. A. Fiske, U. S. N., for determining the range and position of distant objects by the aid of electrical means, and are now able to place before our readers his latest device of this nature. It is intended for use more particularly as a position finder, to be employed on shore, as, for example, in a fortified place at the entrance of a harbor. It enables the position of a ship or other object afloat to be accurately determined, and thus renders it possible to train a gun upon it accurately.

The apparatus consists of two principal parts; namely, a device for determining the distance and a device for determining the direction or bearing of the object. These two parts are used conjointly, and thereby the location of the object may be recognized upon a chart representing the area of the harbor, for example, drawn on a reduced scale. In the accompanying drawings, Fig. 1 is a diagram illustrating the operation of the distance, or range, finder. Fig. 2 is a diagram illustrating the operation both of the range finder and of that part of the apparatus which shows the bearing of the distant object. Fig. 3 is a side elevation of the observer's instrument and shows the mechanism in detail.

Referring first to Fig. 1, *A* is a telescope, located upon an elevation adjacent to the waterway to be protected. The telescope is pivoted at its outer end, so that it can be depressed through any desired angle in order to bring it to bear upon the object. It is provided near its sight end with a contact piece, or wiper, which always bears upon a body of conducting material, represented symbolically at *C*, Fig. 2. Connected with the ends of the body *C* is a battery, *D*, and connected in circuit with one end, *E*, of *C* and with the movable wiper, or contact piece, carried by the telescope is a galvanometer, *F*.

It will be apparent that as the telescope *A* is moved on its pivot, its contact piece, or wiper, will be carried along the body *C*; and, as a consequence, a greater or less amount of it will be brought into the circuit which includes the galvanometer *F*. Inasmuch as the body *C* consists of a wire of uniform resistance per unit of length, it is obvious that as the telescope is moved and a greater or less length of the wire is bought into the galvanometer circuit, the resistance thus interposed in the circuit will be increased or diminished; and as this length, and hence this resistance, depends upon the angle of depression of the telescope, it becomes a function of the angle of depression; and, equally, the deflection of the galvanometer *F*, due to this change, is also a function of the angle of depression. Therefore, knowing the height of the telescope above the level of the object, the galvanometer deflection will indicate the distance of the object from the telescope, for which case the galvanometer may be once for all graduated in any suitable unit, such as metres or yards. Hence, if the galvanometer be located at a station distant from that telescope an observer at that distant station, by reading the galvanometer, can recognize at once the distance of the object, while the person stationed at the telescope has nothing to do but to keep it properly directed upon the object.

The telescope pivot is carried upon a bar, *G*, Fig. 3, which is pivoted upon a circular table, *H*. Placed in a groove around the periphery of this table is a wire, *I*, Fig. 1, of conducting material, having a uniform resistance per unit of length. Upon the bar *G* is supported a contact piece, or wiper, as will be more particularly explained later, which contact piece, or wiper, always bears upon the wire *I*. At the distant station, Fig. 1, there is arranged a circular table, *J*, having around its periphery a wire, *K*,

similar in all respects to the wire *I*. Upon this table is pivoted a bar, *L*, which carries a wiper, or contact point, which constantly presses upon the wire *K*. The contact point on the bar *G* and the contact point of the bar

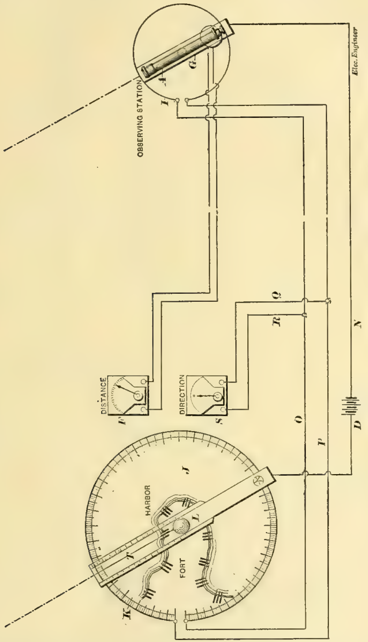


FIG. 1.—DIAGRAM SHOWING METHOD OF OPERATION OF FISKE'S DEPRESSION POSITION FINDER.

L are connected by a wire, *N*, which also includes the battery *D*. The ends of the wires *K* and *I* are connected by wires *O* and *P*, and these wires, *O* and *P*, are respectively connected to wires *Q* and *R* which lead to the terminals of a galvanometer, *S*.

It will be obvious, by a simple inspection of Fig. 1, that the wires *I* and *K* at the separated stations and the pivoted bars *G* and *L*, together with the battery and the galvanometer *S*, are connected in a Wheatstone bridge circuit, and that a movement of either the bar L or the bar *G*, displacing the contact pieces over the wires *K* or *I*, will vary the resistance of the bridge arms, so that the bridge may be brought into or out of equilibrium by the movement of these bars upon their pivots. And further, it will be obvious that the fact when equilibrium is produced in the bridge will be made manifest by the movement of the pointer of the galvanometer *S*. The construction is such, therefore, and the instruments at the separated stations are placed with reference to one another so, that when the bar *L* makes the same azimuth angle with reference to one end of its wire *K* as does the bar *G*, then the bridge will balance and the galvanometer *S* will show zero; so that if the telescope *A*, and consequently the bar *G*, parallel thereto, be directed upon the object, the galvanometer *S* will indicate zero when the bar *L* is placed similarly to the bar *G*.

If then, on the table *J*, there be disposed the chart of the area to be protected, on a reduced scale, such, for example, as is shown in Fig. 1, the direction of the object from the point of observation will be indicated by the position of the bar *L*. For convenience in this respect the bar *L* is made with an opening containing a longitudinal wire, *T*; the position of the object on the chart being, of course, along this wire. On the sides of the opening in the bar *L* there is marked a scale of distances, in yards or metres.

The operation of the whole apparatus will now be readily understood: The telescope *A* is depressed, and also moved in azimuth, until aligned with the object. Inasmuch as the distance of the object depends, as has

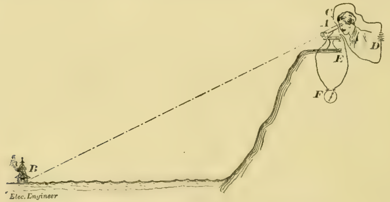


FIG. 2.—FISKE'S DEPRESSION POSITION FINDER.

already been explained, upon the angle of depression, and as this angle is measured by the galvanometer *F* in terms of distance, it is plain that if the galvanometer *F* be located at the station distant from the observer, then from that instrument the distance of the object can at once be read off. Simultaneously the movement of the telescope *A* in azimuth disturbs the balance of the bridge which includes the galvanometer *S*. The observer at the receiving station then moves the bar *L* until the galvanometer *S*, placed near to him, shows zero. When this is done the position of the object will be somewhere along the line of the wire *T*; and its exact point along that wire is immediately found by noting on the scale on the bar *L* the distance corresponding to that shown by the galvanometer *F*.

The receiving stations may be as numerous as desired; in practice, one receiving station is located at each group of guns.

It will be apparent that one of the great advantages of this instrument is that it is directed by a single observer, and that the simple operation of aligning it with the target instantly causes, at the distant station (the bar *L* there being suitably manipulated), indications from which the bearing and distance of the object may at once be recognized.

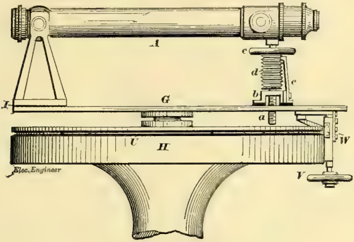


FIG. 3.—FISKE'S DEPRESSION POSITION FINDER.

In Fig. 3 we illustrate, in detail, the mechanical construction of the telescope *A* and its supports. The table *H* has imbedded in it a ring, *U*, of hard rubber, in which ring is the groove in which is placed the wire *I*. The bar *G* is rotated on its pivot by means of the handwheel *V*, the support for which wheel carries the contact point, or wiper. The inner end of the telescope *A* is supported on the vertical screw *a*, which passes through the fixed nut *b*, which is carried on, but insulated from, the bar *G*; the insulation being placed below the nut. The screw *a* is rotated to depress and lower the telescope by means of the handwheel *c*. Secured upon the screw is a cylinder, *d*, of ebonite, having upon its surface a spiral groove in which is laid the German silver wire corresponding to the body *C*, Fig. 2. *e* is a contact spring which always bears upon the wire *C*, and this spring is supported upon, but insulated from, the nut *b*. In this device, instead of causing the telescope *A* to carry the contact and move it over a fixed body, *C*, as in Fig. 2, the body *C*, by the rotation of the screw *a*, is made to move under the fixed contact piece *e*; the relation of the parts being thus merely reversed. The circuit connections are the same as is indicated in Fig. 1; that is to say, the battery terminals lead to both ends of the wire *C* wrapped upon the cylinder *d*, and the terminals of galvanometer *F* connect respectively with the contact wiper *e* and one end of the wire *C*. The movement of the telescope *A* in azimuth is 350 degrees.

A peculiarity of this instrument is the ease with which it can be adjusted for rise and fall of the tide which causes of course a rise and fall of the vessel; and for changes of refraction. For it is plain that it is merely necessary to have a buoy anchored at a known distance, and to manipulate an adjustable resistance in the galvanometer circuit until the galvanometer indicates this distance when the telescope is directed on the buoy.

ARMOR QUESTION PUZZLES.

[*The Engineer*, June 16, 1893.]

Reports come to hand of a curious question which has arisen in connection with ships' armor. As all who have read reports on experiments during the last two years are aware, America and England have, by means of the Harvey and Tresidder processes, broken up the hardest and toughest shot that can be manufactured, by means of a very hard skin which resists the shot sharply and abruptly before it receives any support from the surrounding metal with which it enters. The plates subjected to the Harvey process have, undoubtedly, both at St. Petersburg and at Portsmouth, behaved far the best of all the plates hitherto tried. At the same time it is to be said, in justice to Tresidder, that had his process been applied to plates giving better support than the plastic wrought-iron foundations of our compound plates, it would have given much better results than it did. Harvey's plates have allowed the shot to enter deep in notable earlier cases when the water chilling has been imperfectly performed. Indeed, these magnificent plates to give their best results, depend on three elements over and above the selection and excellence of steel and the skill in working: 1st, the Harvey process of carbonizing the front of the steel so as not only to harden it directly, but also to enable it to be hardened further by chilling; 2d, the chilling by jets of water; 3d, the presence of nickel. The second of these has been, at least, as completely carried out by Tresidder as by Harvey, indeed, until the later experiments, more perfectly performed by means of a sort of gridiron frame of pipes and jets. Harvey's plates now stand first in the field, but the skins of Tresidder's have broken up shot as abruptly as could be conceived; in some instances, indeed, so complete that we have seen plates to which no metal of the shot has adhered, the whole having bounded or slid off, leaving only a slight indent. We mention this fact especially with reference to a curious question which has recently come up, which we propose to notice presently, and which is the main reason for calling attention to the subject. American and English makers have been first in the field with these hard surfaces; doubtless plates are now receiving them on the Continent, but they have not figured yet in any international competitions. Armor, then, has recently made a distinct advance, and has held its own much better against the gun than for many years past. Under these circumstances it must be disheartening to armor-plate makers to be suddenly told that the Russians have discovered a shot which does not mind the plates with hard skins, and holds its own against them nearly as well as against those of an ordinary character. From more than one source the information has come to hand as to what this remarkable Russian shot is. It turns out to be an old friend, or rather, so ephemeral was the part it played in experiments, that it might be termed a "casual visitor" rather than a "friend."

During the series of trials made by General Inglis' plate and projectile sub-committee in 1878, the curious fact transpired that a Palliser projectile which failed to perforate a compound plate when fired directly at it, was able to get through the same plate if an additional wrought iron plate was placed in front of its face. The explanation was that the shot broke up if abruptly stopped in air by striking the hard compound face, while, if it first entered two inches of wrought iron, it received support, and then was enabled to pass unbroken through the entire compound plate. In fact, the energy wasted unprofitably after fracture in the first case was much more than sufficient to carry the shot through two or two and a-half additional inches of iron. Following this up, Major English, we believe, suggested that a cap, or nozzle, of wrought iron on the point of

the shot might produce a similar effect. This was tried, and at first gave some promise, but was very soon given up. It may be easily seen that it was unlikely to act well striking at an angle, as shot do on service. Even directly, however, the benefit was too questionable to be worth further trial. This wrought iron cap, it appears, is the characteristic feature of Russian projectiles. Clearly, conditions are more promising now than in 1878. Then we were dealing with a hard layer extending for some inches into the plate. Now we do not mind the hardness of this thick layer; our real difficulty is with a mere film of adamantine hardness, and the period of support specially needed by the point is consequently decreased, for the Holtzer shot is abundantly able to hold its own against fairly hard steel if once it gets through the film on the face; so that although our past experience was not of an encouraging character, the cap deserves another trial. There are, however, some curious little difficulties about it. In old days the cap was held by pins; now the shot head is hardened by processes that would prove ruinous to the integrity and soundness of a head that had open holes left in it. Is there any method of making the cap adhere to the point? It is only required to hold until the projectile starts fairly on its path, but should it happen to come off before that time in the bore of the gun, it would probably act as a wedge, and burst the piece. This is at present the most interesting feature in armor, but it is not the only doubtful question calling for investigation. We have now various "cross-breeds" of armor-piercing projectiles, if we may term them so, called steel armor-piercing common shell, forged and cast steel common shell, etc., which are coming into active play. Quick-fire has outgrown its original work of dealing with torpedo-boat attack. Quick-fire guns now pour in tough steel shells of various weights up to 100 lbs. each and more, with an energy and bursting charge that may effect destruction of the weaker parts of ships, at such a rapid rate that the extension of thin armor plates has become a necessity, and this can only be made thick enough to deal with the less direct or less heavy blows of the quick-fire guns. With the excellent projectiles now made has come in more acutely the question of carrying high explosives into ships, the possibility of which must greatly depend on the relations of the power of shell to the resistance of armor face; and in connection with this, a number of points arise as to fuze action, safety of high explosive compounds, and others which cannot here be discussed. As we have before noticed, the German shells containing wet gun-cotton charges coated with paraffin gave extraordinary results two years ago, but we have not heard much of them lately. One thing seems obvious, namely, that the rapid progress made in various ways makes it apparent that the older structures, guns and projectiles, have in these days a very poor chance against those of more recent construction.

SEAMLESS STEEL BOATS.

[*The Engineer*, July 14, 1893.]

The problem of building a boat that will be cheap in first cost, free from the effects of heat and wet, strong and light, and which will cost the least for maintenance, has found one solution, as have many other practical problems in engine and shipwork, by the employment of mild steel and the hydraulic press. Boats are now being made out of stamped steel plate. These steel boats, as made by the Seamless Steel Boat Company, are formed in two halves; each half is a thin plate of steel pressed to shape; they are then riveted to a bulb-bar, which forms the stem, keel

and stern-post. The usual equipment is then fitted, and buoyancy chambers either of galvanized iron, wood or copper, as desired. They are also supplied completely fitted to pass the Board of Trade requirements. They are made in all the usual sizes, either as cutters or life-boats, and from 20 feet in length to 28 feet. The weights vary from 14 cwt. to 19 cwt. and the prices from £35 to £53. This is for the Board of Trade scale, which entails an extra charge of between £7 and £10. From the seaman's point of view, these steel boats are in many ways superior to wooden boats, as owing to the smoother surface the skin friction is much less than in wood boats; they, therefore, sail faster and pull easier. Like all improvements in shipping, a good deal of old-time prejudice has to be overcome; but the advantages to the shipowner and seaman are so obvious that in all cases where they have been supplied the reports are, we understand, satisfactory. Thus, in one case of an Australian steamer carrying six boats, two seamless steel boats were supplied. On arrival at Sidney, the captain put all the boats in the water. The wooden ones at once filled, and the only boats that were available for instant service were those of steel, from which it would appear that the captain had taken little care of his wood boats. Among others who have adopted them may be mentioned the Tyne Steamship Company, Crow, Rudolph & Co., W. Tapscott & Co., the Great Eastern Railway Company, the Amazon River Steamship Company, the North German Lloyds, Herr F. Schichau, etc. They are also supplied to the new steamers of the turret type, and are specified for on the large steamers now building for the Wilson Line. Messrs. Clark, Chapman & Co., of Gateshead, are the agents for the Seamless Steel Boat Company.

[NOTE.—By an oversight in reading proof, the professional note entitled "Photographing Flying Bullets" in the last issue, Whole No. 66, was incorrectly credited to the United States Gazette. The article in question was taken from the United Service Gazette.—EDITOR.]

BIBLIOGRAPHIC NOTES.

AMERICAN.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

JUNE, 1893. Phillips' Flying Machine. Manganese Steel. Condensation in Steam Engines. Progress in Flying Machines (continued).

JULY. The Cyclogram of Pressures in Steam Engines. Lubrication of Steam Engines. U. S. Protected Cruiser Olympia. Progress in Flying Machines (continued). Phillips' Flying Machine.

AUGUST. Technical Importance of Aluminum and its Future Applications. Twenty Years' Progress in Turret Ship Construction. The Steering of Balloons. Progress in Flying Machines (continued).

H. S. K.

CASSIERS' MAGAZINE.

MAY, 1893. Modern Gas and Oil Engines, III. Steam Engines at the World's Fair, I. Amount of Water Suspended in Steam.

JUNE. Waste Furnace Heat Under Steam Boilers. Steam Engines at the World's Fair, II. Progress in Heating by Electricity. Modern Gas and Oil Engines, IV.

JULY. From Mine to Furnace.

Description of coal mining and coke making.

Heating Feed Water with Live Steam. Modern Gas and Oil Engines, V. Steam Engines at the World's Fair, III.

AUGUST. From Mine to Furnace. Boilers at the World's Fair, I. Modern Gas and Oil Engines, VI. Anhydrous Ammonia Gas as a Motive Power. H. S. K.

ENGINEERING-MECHANICS.

MAY, 1893. The Constructor. A Few Peculiarities in the Construction of Cranes and Hoists. Graphical Statics and Its Application to Construction. Notes on the Steam Injector.

JUNE. The Constructor. Culm Utilization. The Cramps at the Head. Notes on the Steam Injector. Relative Values of Steaming Coals. Steam and Cylinder Condensation.

JULY. The Constructor. Graphical Statics and Its Application to Construction. Notes on the Steam Injector. H. S. K.

IRON AGE.

VOLUME LI., No. 24, JUNE 15, 1893. Puddling at Lowmoor.

A description of the method pursued in the manufacture of iron.

The Harvey Process. The Torpedo-Boat Forces of Foreign Navies. Testing Deck-Plate Piercing Shells. The Main Battery of the New Battle-Ships. The Duplex Process.

A brief account of the process of manufacture of Basic steel at Witkowitz, Austria.

JUNE 22. Manganese Steel Wheels. The Engineering Congress. Four Days Across the Atlantic.

JUNE 29. The Pittsburgh Gas Engine. The Ehrhardt Process of Making Seamless Tubing. The Ferris Wheel. Enlargement of Cramp's Shipyard.

VOLUME LII., No. 1, JULY 6. Coal Consumption in War Vessels. Krupp and His Workmen.

JULY 13. The Adoption of Water-Tubular Boilers for the British Torpedo Vessel Speedy.

A brief description of the hull, engines, boilers and armament of this vessel. She is to develop 1000 H. P. more, and to attain one knot greater speed, than the other vessels of her class.

Naval Ships and Guns Abroad.

A review of recent naval construction abroad; showing tendency to restrict dimensions of battle-ships and increase those of cruisers; also to decrease the caliber of main batteries.

The Bethlehem Hammer.

A description of the 125-ton hammer; also of the 14,000-ton press.

JULY 20. Testing a Field Telephone Line.

A test, by the U. S. Signal Service, of the Charallois equipment.

Qualities of Smokeless Powder. Cartridges for the Krag-Jörgensen Rifle.

A description and effect of the bullet to be adopted.

High Explosives in Shells.

Recent tests of the Justin shell at Sandy Hook; also a brief description of the Snyder and other methods of firing high explosives in shells.

JULY 27. Shipping Armor Plate.

Recent shipments by the Bethlehem Iron Company.

Submarine Boats for the Navy. The Pierpoint Water-Tube Boiler. A Proposal to Raise the Victoria.

Signor Balsamello, the Italian inventor of the submarine vessel Balla Nautica, has made a proposal to raise the Victoria by using his invention, at a cost less than $200,000.

AUGUST 10. Ships Building for the Navy. Welded Seams in Plates. Mechanical Coaling Device for Steamers.

A description of the invention of M. J. Paul, recently exhibited in England.

AUGUST 17. The Sinking of the Victoria.

An account of the action of the Victoria after she was struck, and the effect of the blow on the bow of the Camperdown.

Bessemer Blowing Engine. Self-Balancing Turbine.

AUGUST 24. Improvements in the Art of Cable Making. The Open-Hearth Process. Brown Wire-Wound Gun and Smokeless Powder.

Brief account of the trial of this gun with the Leonard smokeless powder at Sandy Hook on August 18th.

AUGUST 31. The Open-Hearth Process (conclusion). Water-Tube Boilers for Marine Purposes.

The English Admiralty proposes to make a comparative test of different types of these boilers and the tubulous boilers now in use.

H. O.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

AUGUST, 1893. On the Analysis of Certain Curves Arising in Engineering Investigations. Specifications. Care of Marine Boilers. Conclusions and Recommendations of the Committee Appointed by the Admiralty to Consider Existing Types and Designs of Propelling Machinery and Boilers in H. M. Ships. The Contract Trial of the U. S. S. New York. The International Engineering Congress (at Chicago). The New Torpedo Craft of the British Navy. Amsler's Polar Planimeter. Coffin's Averaging Instrument. H. M. S. Speedy. Sinking of H. M. S. Victoria. Ships. Merchant Steamers.

H. S. K.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

APRIL, 1893. Deep Water from the Great Lakes to the Ocean.

Mr. L. E. Cooley advocates a line by the Great Lakes, St. Lawrence River, Lake Champlain and the Hudson. Some of the statements in his paper will be read with great surprise by those not familiar with his statistics. For instance, he says that the commerce in and out of Lake Superior is greater than that through the Suez Canal; that of the Detroit River greater than that through the Straits of Gibraltar; while the commerce of Chicago is two-thirds that of Liverpool.

On Some Physical Properties of Steel as Related to its Composition and Structure.

Considers the subject mainly on the internal and molecular side.

MAY. A Comparative Test of Two Types of Smokeless Furnace. Steam Engine Efficiency—Its Possibilities and Limitations.

JUNE. The Proposed Deep Waterway from Buffalo to New York City, and Some Facts About the Suez Canal and the Numerous Projected American Isthmus Canals.

Mr. Estabrook's paper is of utmost interest. He does not advocate the route proposed by Mr. Cooley in the April issue, but his arguments, in proof of which he presents much interesting data, are in much the same line and include national defense.

H. S. K.

JOURNAL OF THE FRANKLIN INSTITUTE.

JULY, 1893. Present Development of Heavy Ordnance in the United States (Jaques).

History of the development of heavy gun making in this country during the past ten years (to be continued).

Mark's Improvement on Artificial Limbs.

AUGUST. Present Development of Heavy Ordnance in the United States (concluded).

SEPTEMBER. Carborundum. A New Tele-photo Lens.

The Parvin lens; overcomes distance to a great degree and is suitable for instantaneous work, which latter feature is not found in foreign lenses of this character.

H. S. K.

JOURNAL OF THE MILITARY SERVICE INSTITUTION.

VOLUME XIV., NO. 64, JULY, 1893. Military Sanitation. The Three Battalion Organization.

Captain Edmunds does not believe it adapted to our army.

Organization of the Armies of Europe. Drill. Some Suggestions in Regard to Arms, etc.

Captain Gardener makes many practical suggestions as the result of his experience. Among other things he recommends putting up rations by contractors in multiples of 100 rations, which would be especially useful in time of war by reason of the saving in time in making shipments or issues.

Comment and Criticism: Military Training and its Value in War; Drill Regulations; Musketry Training; The Three Battalion Organization.

SEPTEMBER. Recruiting and Desertion. Army Organization (honorably mentioned prize essay). Small-Arms Firing. The Bear, the Lion and the Porcupine. Comment and Criticism: Army Organization; The Three Battalion Organization; Some Further Suggestions in Regard to Arms; Recruiting and Desertion. Military Criticism and Modern Tactics. Changes and Progress in Military Matters. Concrete and the Action of Sea Water. The Artillery in 1870–71.

H. S. K.

JOURNAL OF THE UNITED STATES ARTILLERY.

VOLUME II., NO. 3, JULY, 1893. Vertical Fire.

Col. Abbott discusses the advantages and disadvantages of mortar fire, and suggests a plan to better regulate the accuracy of fire by arranging the batteries in groups which can be controlled by one person.

The Artillery of the U. S. National Guard. The Forage Ration for Horses of Field Artillery and Cavalry. A Contribution to the Interior Ballistics of Smokeless Powders. A New Powder.

Lieut. Walke discusses the present phase of smokeless powders or compounds, and gives some results obtained from a new powder under development at the Artillery School.

The Artillery-Fire Game (trans.) On the Determination of the Combustion Temperature of Explosives (trans.). Artillery Difficulties in the Next War. Notes on Artillery: The Angle of Jump and Its Measurement; Report of the Tests of the Brown Segmental Tube Wire Gun; Trial of Armor Plates at Gâvre. H. O.

TECHNOLOGY QUARTERLY.

VOLUME V., NO. 4, DECEMBER, 1892. The New Tactics. Weights and Measures of the United States. Action of Compound Dynamos when Run in Parallel.

VOLUME VI., NO. 1, APRIL, 1893. The Course in Naval Architecture at the Institute of Technology.

Professor Cecil H. Peabody reviews briefly the courses at the government schools at Greenwich and Paris, and mentions that at the University of Glasgow, then describes the course of study at the Massachusetts Institute of Technology. His paper was read on January 12, 1893. Since then a regular four years' course in naval architecture, enlarged in scope and improved in details, has been established at the Institute.

Manufacture of Heavy Ordnance with Special Reference to Wire Construction. H. S. K.

FOREIGN.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

XXI. ANNUAL SERIES, 1893, VOLUME V. Quick Voyages of German Sailing Vessels. The Voyage of Discovery of the French Man-of-War Manche and the Island Fisheries. Voyage of the German Cruiser Gneisenau from Bahia to Trinidad, and thence to Grenada, West Indies. Voyage of the German Cruiser Falke from Kameroon to Cape Town. Hydrographic Notes on Tientsin (Taku Bar). The Depth of the Water in the Roads and Harbor of Buenos Aires; also the Harbor Improvements. Voyage from Freemantle to Rockingham, thence to London. Information on Papieti (Tahiti). The Quarantine Regulations of Para, Brazil. Minor Notes: Submarine Sentry; Ice; Bottle-Post; Change in the Tem-

perature of the Air and Water in Running into a Tide-Rip; Fogs in Vladivostock. Meteorological Journals Received at the German Observatory in April, 1893. The Weather on the German Coast in April, 1893.

VOLUME VI. Report on the Results of Magnetic Observations on the German Coast in 1892. Contributions to the Sailing Directions of the Ocean (with Chart). Quick Voyage of German Sailing Vessels. Sailing Directions for Sta. Barbara, Samana Bay, St. Domingo (with Plan), Arecibo, North Coast of Porto Rico (with Plan). Meteorological Observations in the North Atlantic. Voyage of the German Gunboat Hyaene from Kameroon to Lome and Return. Minor Notes: The Effect of Drift-Ice on the Form of the Ocean's Bottom in the Polar Regions. Meteorological Journals Received at the German Observatory in May, 1893. The Weather on the German Coast in May, 1893.

VOLUME VII. Fog Signals (a study). Contributions to the History of the Sailing Directions of the Ocean (continuation). Report on the Results of Magnetic Observations on the German Coast during the Year 1892 (conclusion). Drift-Ice in Southern Latitudes (continuation). Some Observations on the Current Charts of Captain Seemann. Approach to Santa Cruz del Sur, Cuba (Cuatro Reales Channel). The State of the Weather in Samoa in December, 1892, and in Auckland, New Zealand, in March, 1893. Voyage of the German Cruiser Sperber from Apia to the Marshall Islands, New Guinea, Admiralty and Solomon Islands, thence to Sydney. Voyage of the German Cruiser Falke from Cape Town to Kameroon. Voyage of the German Gunboat Iltis from Tientsin to Chefoo, Chemulpo and Shanghai. Voyage of the German Cruiser Leipsig from St. Helena to Porto Grande. The Equipment Facilities and Other Conditions of Buenos Aires Compared to Those of Montevideo. Port Adelaide and Port Victor, South Australia. Minor Notes: Prizes Offered by the Smithsonian Institution out of the Hodgkins Fund. Meteorological Journals received at the German Observatory in June, 1893. The Weather on the German Coast in June, 1893. Currents between Antigua and Guadaloupe. Time Ball at Hong Kong.

H. O.

BOLETÍN DEL CENTRO NAVAL.

MARCH, 1893. Modern Constructions; Plan of a Rapid Cruiser (continued). Forms of Rifle Balls. One Word More Concerning the Belleville Boilers.

APRIL. The Naval School and the Fleet. The Rôle of the Torpedo-Boat, According to an English Idea.

MAY. Annual Report of the Board of Management of the "Centro Naval."

JUNE. Isla de los Estados (Staten Island); Its Light-House and Subprefecture—A Study of Navigation. The Hydrographic Service of England. J. L.

DEUTSCHE HEERES-ZEITUNG.

MAY 31, 1893. Vindication of Captain Prey of the German Army. The Fortress of Langres, 1870–71. Military Notes. Naval Notes.

The Austrian ram-cruiser Maria Theresa was launched on April 29. She is a protected cruiser of 5250 tons displacement; length, 361 feet; breadth, 52 feet 6 inches. Her double bottom extends nearly the entire length of the vessel, and she has numerous water-tight compartments. She has a protective deck of 57 mm. thickness, extending 4 feet below the water-line. Her battery consists of two 24-cm. Krupp guns, 35 cal., mounted on pivot carriage, operated by electricity, in 10-inch steel armored barbette turrets; these guns have an arc of fire of 240°. Also eight 15-cm. Krupp guns mounted in a central citadel protected by 10-inch steel armor. These guns are so arranged that four will bear directly ahead, astern and on either beam, and will deliver at least eight shots per minute. The secondary battery consists of two 7-cm. Uchatius boat guns, eighteen 47 mm. R. F. guns; and two machine-guns of small-arm calibre. She has four torpedo tubes, is provided with torpedo nets, and lighted by electricity. Her engines will develop 7000 H. P. under natural draft, and 9800 H. P. under forced draft, giving a speed of seventeen and nineteen knots respectively. She carries 740 tons coal, and can steam 4000 nautical miles at a speed of ten knots.

Russia has ordered two torpedo-boats of Beklemsscheff type. They are building at the Pulitoff works near St. Petersburg. They will be 125 feet 10 inches in length, and 11 feet 6 inches in breadth, and their machinery will develop 1100 H. P., giving a speed of 18 knots. They are named Moonsund and Hapsal.

JUNE 3. Selected Writings of Archduke Charles of Austria. Military Exercises in France.

Rules governing these during the present year.

Military and Naval Notes.

JUNE 7. Stenography in the Military Service. Theodore v. Bernhardi and General Oldwig v. Natzmer. Military Notes.

JUNE 10. Directions for the Work of Cavalry in the Field. Theodore v. Bernhardi and General Oldwig v. Natzmer (cont.). Military Notes.

JUNE 14. The Servian Army.

Its strength and organization.

Theodore v. Bernhardi and General Oldwig v. Natzmer (conclusion). Military and Naval Notes: The Launch of the German Protected Cruiser Gefion, with a Brief Review of the Ship-Building Industry of Dantzic.

This new vessel is a cruiser of about 5000 tons displacement, with a steel protective deck. She has all the latest improvements in ship-build-

ing, has double bottom, water-tight compartments, electric lights, steam heat and laundry, and a cellulose belt at water-line. She has twin screws and a speed of twenty knots. Her armament will consist of R. F. Krupp guns from 3.7 to 15 cm. calibre. She has two military masts with military tops, which carry four 15 cm. guns.

JUNE 17. German Ships at Hampton Roads.

A comparison of the German ships that took part in the Naval Review with those of the other nations represented.

The French Occupation of Küstrin, 1806–1814. Military and Naval Notes: The Broad Pennant of H. M. the Emperor of Germany.

The Emperor has adopted a pennant to be hoisted at the main of a ship, or at the bow of a boat, to indicate that the honors due to him as sovereign must be suspended, and that he is to receive only those of an admiral afloat.

JUNE 21. From 1807 to 1893.

A criticism of the military history of Germany, by Lieut.-Col. Knorr.

The French Occupation of Küstrin, 1806–1814 (cont.). Military and Naval Notes.

JUNE 24. The French Occupation of Küstrin, 1806–1814 (cont.). Military Notes.

JULY 1. The Sinking of the Victoria. The French Occupation of Küstrin, 1806–1814 (cont.). Military and Naval Notes.

The strength of the German Navy for 1893–94 has been fixed at 19,480 souls. The official corps consists of the Secretary of the Navy, the Commanding Admiral, 10 admirals, 619 line officers, 40 marine officers, 74 engineers, 107 surgeons, 40 ordnance and equipment officers, 31 torpedo and engineer officers; total, 923 officers and surgeons. Also 72 paymasters, 140 sea-cadets, 80 cadets and 14 retired officers. The number of men consists of 626 warrant officers, 2877 petty officers, 13,423 seamen, 7 chief musicians, 149 musicians, 154 mechanics, 154 hospital attendants, 147 paymasters' cadets and applicants, 12 armorers, and 600 boys.

The men are divided as follows: Two seaman divisions of two subdivisions, and one subdivision of boys each, 8404 men; two navy yard divisions of five companies each, 4515 men; two torpedo sections, 1871 men; four marine artillery sections, 2017 men; two sea-battalions of four companies each, 1207 men; and 235 men attached to the artillery and torpedo departments; total, 18,249.

The fleet is composed of 14 battle-ships, 18 armored vessels, 2 frigate-cruisers, 9 corvette cruisers, 8 cruisers, 3 gunboats, 9 dispatch-boats, 11 school-ships, and 12 vessels for other purposes; total, exclusive of torpedo-boats, 86 vessels with total displacement of 25,193 tons and total I. H. P. of 274,420, with a complement of 21,623 men.

JULY 5. Rules for Field-Fortifications in the German Army. The French Occupation of Küstrin, 1806–1814 (cont.). Military and Naval Notes.

JULY 8. The Defence of a Plateau. The French Occupation of Küstrin, 1806–1814 (conclusion). Military and Naval Notes.

JULY 12. Auxiliary Service in the French Army. Historical Vessels. Military and Naval Notes.

JULY 15. The Limits of the Line of Battle. The Battles of Boiscommun and Lorcy, 24 and 26 November, 1870. Military and Naval Notes.

JULY 19. The Adoption of Army Organization by the Chamber of Deputies of France. The Battles of Boiscommun and Lorcy, 24 and 26 November, 1870. Military and Naval Notes.

JULY 22. The New Shipbuilding Programme for the Holland Navy, and the Ram Cruiser, Type A.

Holland proposes to build a new fleet consisting of four types, besides thirteen torpedo-boats. Type A are ram-cruisers of 3400 tons displacement—four of these will be laid down at once. Type B are dispatch vessels of 450 tons—six vessels will compose this class. They will have a speed of 22 knots, and will be of the torpedo-cruiser type. Type C are small vessels of 100 tons, with moderate speed, intended for the defense of the Holland Diep. Type D are vessels of 200 tons, with a speed of 22 knots, intended for the defense of Zuider Zee. It is proposed to build six each of Types A, B and C, and eight of Type D. Also a dispatch-boat, and to re-arm a number of vessels with rapid-firing guns.

The Battles of Boiscommun and Lorcy, 24 and 26 November, 1870 (cont.). Military and Naval Notes.

JULY 26. Some Views on Military Masts and Armored Tops. The Battles of Boiscommun and Lorcy, 24 and 26 November, 1870 (cont.). Military and Naval Notes.

JULY 29. France and Siam. The Battles of Boiscommun and Lorcy, 24 and 26 November, 1870 (cont.). Military and Naval Notes: The Programme of the French Manœuvres for This Year; The Establishment of a Russian Squadron in the Mediterranean Sea.

This squadron will consist of the Dimitri Donskoi (Flagship), General Admiral and Rynda, with several other vessels, under the command of Vice-Admiral Kaznakoff.

AUGUST 2. The March from a Military Point of View. The Battles of Boiscommun and Lorcy, 24 and 26 November, 1870 (cont.). Military and Naval Notes: Instructions for This Year's English Naval Manœuvres.

AUGUST 5. Changes in the Foreign Fleets of Great Britain between July, 1892 and 1893.

A review of the changes that have taken place in the composition of the British naval forces in foreign waters during the past year.

The Battles of Boiscommun and Lorcy (cont.). Military and Naval Notes: The Italian Naval Manœuvres of this Year; The Divisions of the French Navy That Took Part in This Year's Manœuvres; France's Naval Force in the East Indies.

AUGUST 9. The Battles of Boiscommun and Lorcy (conclusion). Military and Naval Notes.

An interesting account of recent torpedo-boat manœuvres in Italy. A fleet of torpedo-boats attacked two men-of-war in Maddalena Harbor. The torpedo fleet consisted of ten vessels, only three of which succeeded in getting into the harbor, but two of these had been discovered and would have been destroyed. One only succeeded in reaching the ships undiscovered and launched its torpedoes; struck the boom around the ships. Similar manœuvres took place at Galta in July.

AUGUST 12. The Infantry Arm of the Future. Numerical Preponderance in the Battles of the Future. Military and Naval Notes.

A memorandum of Vice-Admiral Tryon in relation to implicit obedience to orders issued at the time of the stranding of the Howe. The reorganization of the Spanish Marine Infantry.

AUGUST 23. Crossing of Streams by Cavalry. Numerical Preponderance in the Battles of the Future (cont.). Military and Naval Notes. H. O.

THE ENGINEER.

JUNE 2, 1893. Development of the Use of Aluminium. The Saniter Process. Notice of Brassey's Naval Annual. Duplex Boiler Feed Pump.

JUNE 9. 130-Ton Crane, Glasgow Harbor. New Rifle Barrel and Tube Drilling Machine (Löwe & Co.). High-Pressure Compound Engines. The Regulation of Explosives. Analyses of Engine Tests.

JUNE 16. The Accumulator. Evans' Shaft Turning Machine. Institute of Marine Engineers; Address of Mr. W. H. White, President. Armor Question Puzzles. Oglethorpe's Hydraulic Steering Gear.

JUNE 23. Electrical Engineering at the Chicago Exhibition. Launches of H. M. S. Fox and Charybdis. Harbors and Waterways.

JUNE 30. The Loss of H. M. S. Victoria. The First-Class Cruiser Grafton.

A full description, with data of trials.

Electrical Engineering at the Chicago Exhibition. Analyses of Engine Tests.

JULY 7. Cardiff and its Port. The "Climax" Steam Boiler. Loss of the Victoria. The Utilization of Small Coal.

Notes a process, secret pending application for patents, by which briquettes are made without tar, which burn freely in the characteristic way of the sort of coal from which they are made.

Cylinder Condensation. U. S. Harbor Defense Ram Katahdin.

JULY 14. The Mersey Bar. Hastings Foreshore Protection

Works. H. M. S. Endymion. Seamless Steel Boats. Cochrane's Valve Gear.

JULY 21. The Chicago Exposition—The U. S. Coast and Geodetic Survey. The Institution of Naval Architects.

Notice of papers read and discussions thereon.

Naval Rams (àpropos of the Victoria Disaster). The Present Position of Water-Tube Boilers as Applied to Marine Purposes. The Naval Manœuvres.

JULY 28. The International Maritime Congress.

Notice of papers and discussions.

Harbors and Waterways. Ben Nevis and Its Observatory (Meteorological). Trial of the American Steel Plates (9 and 17 inch). The Naval Manœuvres. An Account of Some Experiments on the Transmission of Heat through Steel Plates from Heated Gas at the One Side to Water at the Other. Trials of the Japanese Cruiser Yoshino. H. M. S. Endymion.

AUGUST 4. Heat Transmission Through Metal Plates. The Stirling Boiler. The Zell Boiler. The Principles of Combustion. The Naval Manœuvres. An Account of Some Experiments on the Transmission of Heat through Steel Plates from Heated Gas at the One Side to Water at the Other (concluded). Battleship Massachusetts.

AUGUST 11. Hydrographic Surveys.

AUGUST 18. A New Rifling Machine (Loewe's). The Motive Power of Small Vessels. The Gill Boiler. Lessons from the Naval Manœuvres, I.

AUGUST 25. Lessons from the Naval Manœuvres, II. The New French Battleships. The Yacht Valiant (owned by Mr. W. K. Vanderbilt). Wick Harbor.

SEPTEMBER 1. Shipbuilding in America, I. Steam Engines at the Chicago Exposition. Lessons from the Naval Manœuvres, III. The Naval Estimates. Steam Engine Economy. H. S. K.

ENGINEERING.

JUNE, 2, 1893. Uppper Egypt Railway Extension. The Iron and Steel Institute.

Notices of the reading of two papers on "Desulphurizing Iron," by Messrs. J. E. Stead and E. H. Saniter, and their discussion; also papers on "A Recording Pyrometer" and "Puddling," the latter being published in full on another page.

A 100-Ton Electrical Locomotive (Heilmann system). The Control of Sparking in Short Air-Space Dynamos. The New Route to the Continent (Harwich to the Hook of Holland, at the mouth of the Maas). The Russian Torpedo-Cruisers Woewoda and Pos-

sadnik. The Engines of the First-Class Cruiser Crescent. The Manufacture of Small-Arms.

JUNE 9. The Regularization of the Danube. A 100-Ton Electrical Locomotive (continued). 130-Ton Crane at Glasgow Harbor. The Manufacture of Small-Arms (continued).

JUNE 16. The Nicaragua Canal. The Krupp Pavilion at Jackson Park. A 100-Ton Electrical Locomotive (concluded). The Fuel Supply of Warships. The New Torpedo Craft.

Description of the "destroyers" Havoc and Hornet, building by Yarrow. They are 180 ft. by 18½ ft., and are to have a speed of 27 knots.

The New Second-Class Cruiser Fox. Watt's Boiler Circulator and Deposit Extractor. H. M. Cruiser Gibraltar.

Description of this 7700-ton sheathed protected cruiser.

JUNE 24. The French Navy Programme. The Hardening of Structural Steel. H. M. Torpedo-Gunboat Speedy. The Manufacture of Small-Arms (concluded).

JUNE 30. Burmah and Its Oil Fields. Notice of the Naval Annual. Steam Boiler Experiments. Engines of H. M. S. Gibraltar. Loss of the Victoria. The Model Battleship Illinois. Condensation in Steam Cylinders.

JULY 7. The Model Battleship Illinois (concluded). The New Electric Lighthouse of Havre. Engines for Dr. Nansen's Polar Expedition Ship Fram. The Stranding of H. M. S. Howe. Transmission and Distribution of Power by Compressed Air.

JULY 14. The New Electric Lighthouse of Havre. The Harris Feed-Water Filter. Notice of the Summer Meeting of the Institution of Naval Architects, and Papers on Oil Steamers, and Fast Ocean Steamships. Ship Railways.

Mr. Kinipple discusses ship railways in general, as compared with canals, and describes his own inventions in this direction. He claims that in three years the Atlantic and Pacific ends of the Panama Canal could be finished and connected by a ship railway of his design for not more than £5,000,000.

Oil-Carrying Steamers.

JULY 21. Institution of Naval Architects.

Notices of papers on "Some Experiments on the Combination of Induced Draught and Hot Air Applied to Marine Boilers Fitted with Serve Tubes and Retarders," "Wear and Tear in Ballast Tanks," "Transmission of Heat through Plates," "Water-Tube Boilers," and "The Strength of Bulkheads"; and discussions.

Dover Harbor Extension. The International Maritime Congress.

Notice of meeting in London, and of papers on the harbors of Middlegrunden and Copenhagen, on breakwaters and sea defences in Italy, compressed air fog signals, ship signal lights, and communication between lightships and shore.

The Extension of a Graving Dock at Leghorn. Oil-Carrying Steamers. Water-Tube Marine Boilers.

JULY 28. The International Maritime Congress.

Notices of further papers and discussions; among them papers on the port of Bordeaux, management of commercial ports, steam communication with the continent, ocean passenger steamships, and on dredging the Mersey bar.

150-Ton Electric Travelling Crane at Creusôt. Shipping and Shipbuilding. Lighting Estuaries and Rivers. Parsons' Steam-Turbine Dynamo. Water-Tube Marine Boilers.

AUGUST 4. The International Maritime Congress.

Papers on the ports of Calais, Dunkirk and Venice, ports on sandy coasts, and lighthouse illumination.

The Extension of the Port of Dunkirk. The Electric Light of Lighthouses. Shipowners and Shipbuilders.

AUGUST 11. The Naval Manœuvres. H. M. S. Theseus. Engine Vibration. The Extension of the Port of Dunkirk.

AUGUST 18. The International Maritime Congress.

Notice of papers, and discussions, on the following subjects: "Marine Boiler Construction," "Shipowners and Shipbuilders," "Concrete in Sea Works," "Recent Improvements in Lighthouses," "Comparison of Gas and Electric Light in Lighthouses with Optical Apparatus of Large Dimensions," "The Turkish and Egyptian Lighting and Light Dues in the Red Sea."

125-Ton Hammer, Bethlehem Iron Co. Engines of the Iberia. Our Engineering Navy. Test of a Bethlehem Armor Plate (17-inch, curved). The Electric Light of Lighthouses.

AUGUST 25. Bilbao Harbor Works. Gun Trials of H. M. S. Ramillies. Lighting and Light Dues in the Red Sea. The Electric Light of Lighthouses (concluded).

SEPTEMBER 1. Beam Engines for Paddle Steamers. The Navy Estimates. Marine Boiler Construction. Fast Ocean Steamships. The Port of Venice. H. S. K.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

VOL. XXXVII., NO. 184, JUNE, 1893. The Art of Marching. Volunteer Transport. Cruisers, their Rôle and the Conditions Which They Should Satisfy. Recent Progress in Marine Machinery. Russian Naval Manœuvres of 1892. Naval and Military Notes.

JULY. Military Organization Best Adapted to Imperial Needs. Best Type of Field Gun for British Service. Mobilization of the Volunteers. The Battleships of England (continuation). A Foreign Notice of Mr. Williams' "The Steam Navy of England." Naval and Military Notes.

AUGUST. Universal Compulsory Service for the United Kingdom.

Photography of Flying Bullets by the Light of the Electric Spark (Boys). How Best to Secure Continuity in the Effective Service of Modern Ships of War for Successive Commissions.

Mr. Williams, R. N., Chief Inspector of Machinery, suggests two plans for the Engineers' force: 1. For ships re-commissioning; in these he recommends making a certain number of changes each year. 2. For ships laid up for repairs and re-fitting, he recommends entering each year an additional number of engine-room artificers to be employed in making repairs to the machinery of ships fitting out. These men to be selected from ships going out of commission, and then to be changed partially each year.

An XVIIIth Century Thermopylæ. Submerged Discharge for Whitehead Torpedoes (translation). Submerged Discharge of Auto-Mobile Torpedoes (extract). German Instructions for Pioneering Duties of Cavalry. Naval and Military Notes. H. O.

JOURNAL AND PROCEEDINGS OF THE UNITED SERVICE INSTITUTION OF NEW SOUTH WALES.

Vol. IV., 1892. Commissariat and Transport. The Encouragement of Useful Rifle Shooting. A Proposed Time Fuze.

Lieut. Gaunt, R. N., proposes a fuze carrying a multiple-winged fan, straight (or with a slight pitch to be determined for different natures). This fan he considers would be held steady by air pressure during flight, the projectile turning about its spindle. By means of clockwork a needle is released at the proper time for which the fuze is adjusted, and the shell is exploded. His fuze has not yet been practically tested.

H. S. K.

MÉMOIRES ET COMPTE RENDU DES TRAVAUX DE LA SOCIÉTÉ DES INGÉNIEURS CIVILS.

February, 1893. The Schwœrer Superheater. About Velocipedy and Its Rapid Development by the Use of the Pneumatic Tire. The Problem of the Direction of Balloons.

March. The Use of Telephones in Railways: 1st Part, Various Appliances of the Telephone and Its Installations; 2d Part, Technical Study of the Apparatus.

April. A Study of the Flexion of Uprights in Bridges with Top Cross-pieces.

May. Note on the Action of the Wind on Metallic Bridges of Continuous Beams.

June. The Canal Between the Baltic and the North Sea.

J. L.

MILITÄR-WOCHENBLATT.

May 31, 1893. How May Cavalry Expeditions be Successfully Conducted? Target Practice of the Swiss Infantry during 1893.

June 3. The Train Organization of the Russian Army. A

Proposition to Facilitate the Discovery of the Wounded on the Battlefield.

The writer suggests a telescopic mast of aluminium, with a lighting apparatus. The mast can be 25 m. high, and is easily transported.

1805 and 1870.

JUNE 7. 1805 and 1870 (conclusion). On the Bursting of Gun-Barrels and Cannon. The Austrian Ram-Cruiser Maria Theresa.

JUNE 10. On Losses in Battle. On the Bursting of Gun-Barrels and Cannon.

JUNE 14. Recent Artillery Tests in England.

A review of the recent attempt to attain high muzzle velocities by increasing the length of a six-inch gun to 100 cal. by screwing on a tube. A velocity of 1130 m. was obtained.

JUNE 17. Front and Flank Attacks. The Present Organization, Strength and Distribution of the French Cavalry. The Siberian Railway; Its Economical, Political and Strategical Importance.

JUNE 21. The Siberian Railway; Its Economical, Political and Strategical Importance (conc.) The Italian Naval Budget.

About 20,000,000 dollars will be expended for naval purposes, of which about 5,000,000 dollars will be devoted to new ships. There are now building, or about to be laid down, four ships of the first class, seven of the second class, six of the third class, and a number of torpedo-boats and harbor vessels.

High Muzzle Velocities in Arms.

A review of the development of high muzzle velocities in recent years.

JUNE 24. Some Suggestions for Drill Regulations of Cavalry. The Naval Policy of the United States.

An account of the distribution of the U. S. Navy after the Naval Review.

Projected Regulations for Garrison and Watch Duty, and the Conduct of Troops in Case of Disturbance and Riot.

JUNE 28. The Loss of H. M. S. Victoria. Strategic Railroads of France.

JULY 1. Past and Future Advanced Posts. Supplement to German Navy List. Promotion in the German Army.

JULY 5. Past and Future Advanced Posts (cont.) The Reorganization of the French Army.

JULY 8. Summer Exercises of the Troops in the St. Petersburg Military District. Past and Future Advanced Posts (conclusion).

JULY 12. The French Naval Budget for 1894. Army Reorganization in Sweden.

JULY 15. Criticism of Krupp's Exhibit at the Chicago Fair.

JULY 22. The Work of Cavalry in the Field. Field-Pioneer Service of the French Infantry.

JULY 29. Review of the Latest Discoveries and Inventions in the Military and Technical Field.

AUGUST 2. Review of the Latest Discoveries and Inventions in the Military and Technical Field (cont.). Tactical Conclusions from the Battle of Worth.

AUGUST 5. Tactical Conclusions from the Battle of Worth (cont.). Review of the Latest Discoveries and Inventions in the Military and Technical Field. The Military Academy at West Point.

A brief description of the Academy, and system of education followed there.

AUGUST 9. Tactical Conclusions from the Battle of Worth (cont.). Two New Heavy Guns in Russia.

AUGUST 16. Changes in French Army Organization. The Italian Army Budget.

SUPPLEMENT TO MILITÄR-WOCHENBLATT.

VOLUMES 5 AND 6, 1893. Military Notes During a Sojourn in the Caucasus and in Persia, by the late Gen. v. Grolman, of the German Army.

VOLUMES 7 AND 8. The Marching Order and Accomplishments of the French under Napoleon.

A lecture by Captain v. Freytag-Loringhoven, delivered before the Berlin Military Society.

The Russian Military System as It Is, and as It Should Be.

VOLUME 9. Biography of General Rudolph v. Roerdansz, of the German Army, by Captain v. Eck. H. O.

MINUTES AND PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS.

PART II., 1892–93. Electrical Railways: The City and South London Railway (discussion). Selected Papers: Westport Harbor Works, N. Z. Abstracts: Influence of Cold on the Strength of Iron and Steel; On the Hardening of Steel; Some Experiments on the Effects of Punching Steel Plates.

PART III. Plant for Harbor and Sea Works (discussion). The Breakdown of the R. M. S. Umbria (discussion). Selected Papers: Radial Valve Gears (analysis of the motion of the valve, with 22 cuts). Abstracts: New Waterway to Rotterdam; Floating Lights; Harbor of Tandjong Priok, near Batavia; Economy of Superheated Steam; Inexplosible Steam Boilers; Steam Jackets in Compound Engines; New Method of Casting Steel Ingots; Recent Trials of Anchors in the Imperial (German) Navy. H. S. K.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XXI., NOS. 4 AND 5. The Scientific Expeditions of the Austrian Man-of-War Pola. The Use of Hydraulic Power on Board French Ships of War. The Conduct of Modern Naval War in its Relation to the Merchant Marine of Great Britain. The English Naval Budget for 1893–94. The Danish Naval Budget for 1893–94. The Naval Budget of the United States for 1893. The French Cruiser, 2d Class, Le Descartes. The Manner of Launching the French Armored Cruiser Chamer. Two Economical Steamer Voyages. Electric Boats. Trial of the New English 12-Pdr. R. F. Gun. The Use of Steam Jackets in Compound and Triple Expansion Engines. Trial of the Vicker's Plate in England. The Fastest French Mail Steamer. The Telephoto (trans.). The Seaworthiness of H. M. S. Royal Sovereign. Liquid Fuel on board Ship. The Establishment of Meteorological Observation Stations in the Atlantic. Trials of French Converted R. P. Guns. New Regulations of the English Board of Trade in Regard to the Position of Side-Lights. Foundering of the French Dispatch-Boat La Bourdonnais. The Netherland Rams, Type A. The U. S. Battleship Iowa. Trial of the English Torpedo-Boat Vulcan. Reform in the Nautical Schools of Italy. The Force of the Wind During a Bora, or N. E. Storm, at Trieste.

By an invention by Mr. E. Mazelle the velocity of the wind during a heavy gust in a Bora, or N. E. gale, was ascertained to have reached 65.3 m. per second, or 235 km. per minute.

Test of Armor Plates at Bethlehem, Pa. Pilots in the German Torpedo Division.

The rank of torpedo pilot and chief torpedo pilot has been established. They are warrant officers. The requirements are good conduct and the capacity to take a torpedo-boat to sea and handle her in squadron.

A New Light.

A new light has been invented with a 40,000 candle power.

Guns of Extraordinary Length. The Argentine Cruiser 9 de Julio. The Voyage of the New Caravel Santa Maria across the Atlantic. New Azimuth Diagrams. New Ships for the French Navy. The New Torpedo-Cruiser Colatafuin, Recently Launched at Castellamare.

SUPPLEMENT TO NOS. 4 AND 5.

The Westinghouse Motor.

A full description.

NOS. 6 AND 7. Landing Operations. The Marmesmann Tubes; Their Manufacture and their Application to War Purposes. Lieut. Lephay's Arrangement for Illuminating the Compass. Conclusions of the Admiralty Commission on Steam Boilers. The Administration and Organization of the Navy of the United States. The Latest Improvements in the Howell Torpedo. The Giffard Gun.

A New Method of Fitting the Tubes in Boilers. The Cruiser, and the Requirements to Make Her Efficient. The Number of Cruisers to that of Merchant Ships in the Different States. French War-Ships Recently Launched. The Seaworthiness of the French Battle-ship Hoche. Fire-Extinguishers for Ship's Use. The Salvage of the Howe. New Ships Proposed for the French Navy. Trial of a Vickers Plate in France. The Periskof Submarine Boats. Trial Runs of English Warships. The Cost of Bronze Propellers. The Facsimile of the Viking Ship. The English Torpedo-Catcher Speedy. Balla Nautica—a New Submarine Boat. Anti-Friction Substance for Bearings, without Oil. The Use of Petroleum and Naphtha for Boats and Small Vessels. The Sinking of the Victoria.

Official reports of Rear-Admiral Markham, Captain Bourke, Commander Smith, Flag-Lieut. Gillford and Lieut. Heath.

H. O.

LE MONITEUR DE LA FLOTTE.

June 3, 1893. The Navy Budget, and the New Naval Constructions. Characteristics of the Vessels to be Put on the Stocks in 1894.

June 10. Increase of Dry-Dock Facilities in the Port of Toulon.

July 1. Apropos of the Loss of the Victoria.

July 8. Discussion of the Navy Budget for 1894.

July 22. The Grand Naval Manœuvres in the Channel.

August 12. Transformation of the Matériel of the Navy.

J. L.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

July, 1893. Abstract of the Proceedings of the Fifty-Sixth Annual General Meeting of the Royal Artillery Institution. The Attack of a Coast Fortress.

Three interesting and instructive essays on the subject.

H. O.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS.

October, 1892. Second Report of the Research Committee on the Value of the Steam Jacket. Experiments on the Arrangement of the Surface of a Screw Propeller. H. S. K.

REVISTA MARITIMA BRAZILEIRA.

March, 1893. Autobiography of a Whitehead Torpedo (from the English) (cont.). The Cruiser Tiradentes. Powders and Explosives. A Plan for the Distribution and Equipment of Meteorological Stations.

April. Autobiography of a Whitehead Torpedo (from the English) (cont.). A Plan for the Distribution and Equipment of Meteorological Stations. Powders and Explosives.

MAY. Autobiography of a Whitehead Torpedo (from the English) (cont.). The Torpedo Gun. A Plan for the Distribution and Equipment of Meteorological Stations. The United States Navy. An Instrument for Determining the Variation and Deviation of the Compass. J. L.

REVISTA TECNOLÓGICO INDUSTRIAL.

MAY, 1893. Resistance of Materials; A Study of the Tests of Iron and Steel. Descriptive and Rational Chemistry.

JUNE. Electric Railroad of High Speed Between Chicago and St. Louis, Building Under the Supervision of Dr. Wellington Adams. A New Disinfectant (V., No. 5). J. L.

RÈVUE MARITIME ET COLONIALE.

JUNE, 1893. Notes on the Left Banks and Navigability of the Middle Me-Kong River. An Essay upon the Research for the Best Order of Combat. Indication and Control of the Compass Route by Means of Luminous Guide-Marks (Repères). Circulation of Wind and Rain in the Atmosphere (ended). Historical Studies of the Military Marine of France (cont.).

JULY. General Observations Regarding the Electric Plant on Board Men-of-War. Mechanical Theory of the Walking Pace and Running Pace. Congress of the French Association for the Advancement of Science. A Study of the Civil and Military Organization of China and of the Province of Kwang-Si.

AUGUST. A New Star-Gazing Planisphere. Vocabulary of Powders and Explosives (cont.) A Study of the Organization of the Coast Defense of the United States. A Notice on the Invariable Plan of the Solar System. A Method for Pointing Coast Defense Guns in Order to Better Utilize the Instantaneous Indications of the Telemeter. Historical Studies of the Military Marine of France (cont.). J. L.

THE STEAMSHIP.

MAY, 1893. Weir's Patent Evaporators for the French Navy. Institution of Naval Architects.

Notices of papers and discussions on "The Strength of Bulkheads," "Boilers and Boiler Tubes," "Testing of Boilers," "Vibrations of Steamers," "Working Triple-Expansion Engines as Compound," and "Approximate Curves of Stability."

The Cyclogram of Pressures in Steam Engines. The New American-Built Atlantic Liners. Sizing of Marine Engines.

JUNE. Mudd's Patent Tail-Shaft Preserver. The Draughtometer. Speed Constants of Ships. The Coaling of Steamers. The Lubrication of Marine Engines.

JULY. Theory of the Mechanical Propulsion of Ships, I. Address of Mr. W. H. White before the Institute of Marine Engineers. The Worthington Company's Steam Pumps (illus.). The Lubrication of Marine Engines. Coal Consumption of Ships of War.

AUGUST. The U. S. Armored Harbor Defense Ram Katahdin. Theory of the Mechanical Propulsion of Ships, II. Worthington Patent Marine Feed-Water Heater.

SEPTEMBER. Theory of the Mechanical Propulsion of Ships, III. Wear and Tear in Ballast Tanks. Van Duzer-Mason Electric Steering Gear. Efficiency of Propellers. Bridge and Engine-Room Communication. H. S. K.

UNITED SERVICE GAZETTE.

JUNE 10, 1893. Promotion from the Ranks in the Navy. Coal Consumption of Ships of War. Russia and the Pamirs. The Future of the Navy.

JUNE 17. The New Defenses of France, IV. Infantry Fire Efficiency. Coal Endurance of Warships.

JUNE 24. The Loss of the Victoria. Mobilization for Home Defense. The French Naval Estimates.

JULY 1. Coast Artillery Practice. Recent Naval Literature. The Disaster to the Victoria. Coast Defense.

JULY 8. The New Defenses of France, V. The Loss of the Victoria.

JULY 15. The Armed Strength of Europe. Naval Manœuvres, 1893. The Relative Strength of Our Navy. The Ram and the Gun.

JULY 22. The Victoria Court-Martial. The Attack of a Coast Fortress.

AUGUST 5. The Naval Manœuvres. A Tremendous Indictment. A Rifle Trenching-Tool.

AUGUST 12. The Naval Manœuvres. The Krnka-Hebler Tubular Projectiles, I. Naval Manœuvres and their Teaching. Gunnery, Past and Present.

AUGUST 19, The Krnka-Hebler Tubular Projectiles, II. Engine-Room Complements of Men-of-War.

Correspondence, in full, on the above subject between the First Lord of the Admiralty and Messrs. John Penn, William Mather, James Kitson, William Allan, and G. W. Wolff, all members of Parliament and well-known engineers.

AUGUST 26. The Naval Warrant Officers. How the French Arrived at Bangkok. The Krnka-Hebler Tubular Projectiles, III. The Relative Strength of Our Navy.

SEPTEMBER 2. The Late Naval Manœuvres (Umpires' decisions).

The Navy Estimates Debate. The Relative Strength of Our Navy. The Powerful and Terrible.

Description of the two 14,000-ton cruisers provided for in the English estimates for 1893-4.

H. S. K.

LE YACHT.

June 3, 1893. The Events of the Me-Kong; Our Naval Forces Outside of European Waters (E. Weyl). Quest for a Type of Racing Yacht Complying with the New Formula of Measurement.

June 10. The Navy Budget for 1894 (E. Weyl). Quest for a Type of Racing Yacht Complying with the New Formula of Measurement. The French Squadron on the Coast of Galicia (Spain).

June 17. The Cruiser Entrecasteaux. Quest for a Type of Racing Yacht Complying with the New Formula of Measurement.

June 24. The Grand Naval Manœuvres of 1893 (E. Weyl).

July 1 and 8. The Loss of the Armored Battleship Victoria; Official Reports of Admiral Markham and Commander Bourke on the Loss of the Victoria.

July 15. The Navy Budget in the French Chamber. The Navy List in the Senate.

July 22. The Grand Naval Manœuvres. The Affair of Paknam. The New Steamers of the Cunard Line.

July 29. The Blockade of the Coast of Siam.

August 5. Verdict of the Court-Martial on the Loss of the Victoria. The Siamese Conflict (E. Weyl). The Second-Class Cruisers Chasseloup, Laubat, Bugeaud and Friand.

August 12. The English Naval Manœuvres. The Launch of the Second-Class Cruiser Suchet. J. L.

EXCHANGES, BOOKS AND PERIODICALS RECEIVED.

American Chemical Journal.
American Engineer and Railroad Journal.
American Shipbuilder.
Annalen der Hydrographie und Maritimen Meteorologie.
Army and Naval Magazine.
Army and Navy Journal.
Army and Navy Register.
Boletín del Centro Naval.
Bulletin of the American Geographical Society.
Bulletin of the American Iron and Steel Association.
Bulletin of the Geographical Society of California.
Cassier's Magazine.

Chilean Revolution of 1891; The Office of Naval Intelligence: War Series, No. IV.
Colliery Engineer.
Deutsche Heeres-Zeitung.
Electrical Engineer.
Electrical Review.
Engineer, New York.
Engineer, London.
Engineering.
Engineering-Mechanics.
Engineering News and American Railroad Journal.
Geological Survey of Missouri.
Iron Age.
Journal and Proceedings of the United Service Institution of New South Wales.
Journal of the American Society of Naval Engineers.
Journal of the Association of Engineering Societies.
Journal of the Franklin Institute.
Journal of the Military Service Institution.
Journal of the Royal United Service Institution.
Journal of the United States Artillery.
Journal of the United States Cavalry Association.
Lend-a-Hand.
Mémoires et Compte Rendu des Travaux de le Société des Ingénieurs Civils.
Militär-Wochenblatt.
Minutes and Proceedings of the Institution of Civil Engineers.
Missouri Geological Survey, Volumes 1, 2 and 3, 1891 and 1892.
Mittheilungen aus dem Gebiete des Seewesens.
Mittheilungen des Vereins für Erdkunde zu Leipzig.
Le Moniteur de la Flotte.
Norsk Tidsskrift for Sovaesen.
Our Navy; The Journal of the Men and Apprentices of the Navy.
Proceedings of the American Philosophical Society.
Proceedings of the Institution of Mechanical Engineers.
Proceedings of the Royal Artillery Institution.
Railroad Gazette.
Revista Maritima Brazileira.
Revista Tecnológico Industrial.
Revue du Cercle Militaire.
Revue Maritime et Coloniale.
Rivista di Artiglieria e Genio.
Rivista Marrittima, Rome.
School of Mines Quarterly.
Seaboard.

STEAMSHIP.
TECHNOLOGY QUARTERLY AND THE PROCEEDINGS OF THE SOCIETY OF ARTS.
TEKNISK TIDSKRIFT.
TIDSKRIFT I SJÖVÄSENDET.
TRANSACTIONS OF THE AMERICAN INSTITUTE OF MINING ENGINEERS.
TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.
TRANSACTIONS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
TRANSACTIONS OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.
TRANSACTIONS OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.
UNITED SERVICE.
UNITED SERVICE GAZETTE.
WORLD'S FAIR ELECTRICAL ENGINEERING.
LE YACHT.

REVIEWERS AND TRANSLATORS.

Lieutenant HUGO OSTERHAUS, Professor JULES LEROUX,
Lieutenant H. S. KNAPP.

SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1894.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules :

1. The award for the Prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1894. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute ; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control ; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

H. S. KNAPP,
Lieut., U. S. N., Secretary and Treasurer.

ANNAPOLIS, MD., *January* 3, 1893.

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PROCEEDINGS

OF THE

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THE PROCEEDINGS

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NOTES ON NAVAL DYNAMO MACHINERY.

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The steady development of marine dynamo machinery and the number of applications opening for its further use aboard men-of-war, render the subject of direct importance to every student of naval construction or equipment. Recognizing the interest felt throughout the service in electrical matters, it affords me pleasure to comply with the invitation of the Board of Control to contribute a paper on the subject.

An inspection of the systems and electrical apparatus in use in the different European navies in 1891, followed by duty at the New York Navy Yard, where the electrical plants of nearly all the vessels of the Navy have come under my inspection, has demonstrated to my satisfaction the two facts that our electrical plants are in most respects superior to those in use in other navies, but deteriorate more rapidly.

It has been the practice of the Bureau of Navigation, and later of the Bureau of Equipment, to publish in the Naval Intelligence Annuals general descriptions of the apparatus introduced in our ships, and the articles therein contained cover the subject very

fully. As no article of the kind appears in the last Annual, the attempt will be made to partly cover the subject in this paper.

The Bureau of Equipment now issues standard specifications for nearly all of the electrical material used aboard ship.

The specifications for generating sets were referred to in the Intelligence Annual for 1892, and an illustration given of an eight-kilowatt set, of the new type, as constructed by the General Electric Co. The principal points of the specifications which determined the construction of this type were the continuous operation of the engines without oil in the steam spaces, the provision limiting the heating of the dynamo, and the absence of external magnetic field. Two eight-kilowatt sets of this type have been placed aboard the Concord, and two others aboard the Bennington. Sixteen-kilowatt sets are in use on the Dolphin, Detroit and New York, while thirty-two-kilowatt sets, shown in Fig. 1, are also installed aboard the latter vessel. Similar sets of various sizes are constructed and in process of installation aboard the Maine, Cincinnati, Raleigh, Montgomery, Marblehead, Columbia, Puritan, Terror and Amphitrite. Under these circumstances a few details may be of interest.

The finished weights and dimensions are as follows :

	Weight.	Length.	Width.	Height.	Watts per lb.
400 amperes,	11,100 lbs.	9 ft. 2 in.	4 ft. 1 in.	5 ft. 9¾ in.	2.89
300 amperes,	9,100 lbs.	8 ft. ¾ in.	3 ft. 10⅛ in.	5 ft. 5½ in.	2.64
200 amperes,	6,160 lbs.	6 ft. 9½ in.	3 ft. 4½ in.	5 ft. ¼ in.	2.60
100 amperes,	3,750 lbs.	5 ft. 6¼ in.	2 ft. 10 in.	4 ft. 9 in.	2.13

The construction of the engines is much heavier than was formerly the case, the number of breakages of those in use in the service having apparently shown that strength had been unduly sacrificed to decrease weight. The new engines have more clearance in the cylinders, and although this is uneconomical so far as steam is concerned, it is of value when working with wet steam or when threatened by water. As the presence of water in the cylinder has always been a cause of damage to dynamo plants, special attention is given to drainage, and the cylinders are fitted with both hand and automatic relief valves. The governor is of the common automatic type, the weights being placed in a wheel midway between the cranks. The space allowed is barely sufficient in the smaller engines, and they do not govern as closely as the

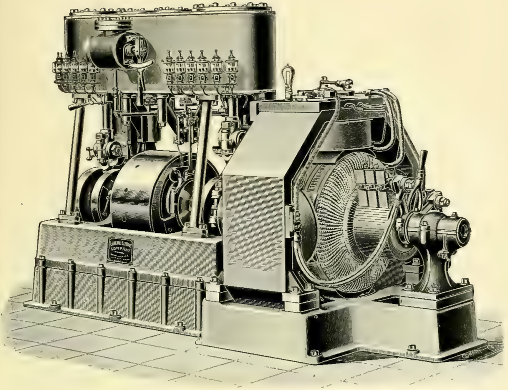


FIG. 1.

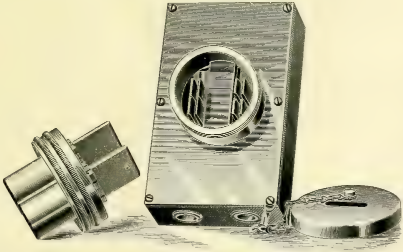


FIG. 2.

larger sizes. The closest regulation has been obtained from the 24 K. W. sets which, on test for acceptance, averaged only five revolutions change of speed from full load to no load, the momentary increase, when all load was thrown off suddenly, being only eight revolutions. The requirement of the specifications, that the variation of speed should not exceed eight revolutions when the steam pressure changed from sixty to one hundred pounds, necessitates considerable reserve power at ordinary working pressures, and even more was furnished, the engines having carried full load on the dynamos at thirty-five pounds pressure, although intended for eighty, and at the latter pressure having under test carried double load. The pistons are without packing rings, and all four sizes of the engines have the same stroke, six inches, the cylinder diameters being respectively 13, $10\frac{3}{4}$, $8\frac{1}{2}$ and $6\frac{1}{2}$ inches. All bearings are of gun-metal except in the 32 K. W. sets, where the crank-pin boxes are partially babbitted. The cranks are set at 90°, causing a poor balance and consequent noisy working, probably the most serious defect of the engine.

The dynamos are four-pole, compound wound. The frame and field cores are of cast steel in one piece, the pole pieces being bolted on. The field coils are cylindrical and wound on vulcabeston spools, the spools on the small dynamos being coned, on account of the lack of room. The series coils are next the core, the ends being brought out directly opposite each other, and all four spools are coupled in series. The shunt winding is outside the series, and the spools are also in series. This arrangement greatly facilitates repairs, as a defective spool can be removed and rewound without touching the others.*

The shape of the field frame and the position of the coils are such as to minimize all external magnetic field. No magnetism can be detected on the outer part of the frames except in one or

* The arrangement of the field magnets has been modified in dynamos for the Boston, Atlanta, Texas and the battleships. In the new type the frame is divided horizontally, the upper half lifting off, while the cores and pole pieces are cast together, and each core bolted to the frame, so that the axes of the cores are inclined 45° to the vertical and horizontal instead of being in those planes. The armature has its own shaft, which is rigidly coupled to that of the engine, but is in other respects unchanged. The battleships will have a new type of engine, which is somewhat smaller but better balanced than the one described in the text.

two positions, and the external field is imperceptible on a horizontal force instrument at a distance of fifteen feet. While it may be urged that the influence of a dynamo placed in an iron compartment is imperceptible on a compass at a distance, there are instances on record in which peculiar arrangements of steel bulkheads have resulted in a deflection of the compass whenever the dynamos were in operation. This magnetic effect could be easily counteracted, but the present policy of entirely preventing it is a most effective safeguard. The multipolar type of dynamo allows of reduction of weight, although necessitating somewhat greater floor space.

The armatures of the new type dynamos are Gramme wound, and slide off and on a shaft common to both engine and dynamo, being secured by a feather and slot and kept in place by set-screws. The armature is built up of soft iron discs, clamped together, there being no through bolts. In the first armature constructed for the 16 K. W. (200 ampere) dynamos, it was found on making efficiency tests that the total core loss due to eddy and foucault currents in the mass of the armature itself was 1207 watts, and the armature, when run on open circuit, the field being separately excited, heated to 22° F. above the air in two and three-quarter hours. As the limit of heating in a full load run of four hours is 50°, this allowed but little margin for the heating due to the current, and armatures tested under these conditions heated from 60° to 80° above the air. A new type of construction was therefore adopted. The core discs were held together by clamps, all through bolts being removed and the discs themselves being carefully insulated. The armature winding was also changed, being made of stranded conductors, each wire being separately insulated before stranding. The effect of these changes was most marked, the total core losses falling below 700 watts, and heating on the full load run of four hours to about 45° F.

The commutator is of bronze, the number of segments varying from 120 to 144 in the different sizes. The commutator has cross connections inside for use with two sets of brushes.

As a result of the range of steam pressure called for under the engine specifications, and of the low heating limit allowed for the dynamo, the generating set possesses great reserve power. In one of the tests, while operating two 200-ampere dynamos in

multiple with about 80 pounds of steam, the whole load of 400 amperes was inadvertently thrown on one dynamo. No noticeable diminution of speed of the engine occurred, nor was there any sparking on the dynamo, and the overloading was manifest only on the ammeter. When the double load of 400 amperes was thrown off it was not necessary to adjust the brushes, the sparking being insignificant. This capacity for carrying an overload is of the greatest value in ship work, as, in case of damage to one set, all the work could be done by another. There is no question of the capacity of the dynamo to carry one hundred and fifty per cent. of its rated load for long runs without material damage, nor is there any lack of power in the engine. In any particular case, the amount of safe overloading would probably depend upon the heating of engine bearings and crank pins.

All dynamos as yet used in our service, have been fitted with rheostats in the shunt field, to admit of variation of the voltage. This design has found but little favor in other countries, either for commercial or marine work, but it is universally adopted in the United States, and the ease of adjustment thus obtained is so great that no other system is considered. Commercial practice also includes an adjustable resistance in parallel to the series field, and this is authorized on board ship when the dynamos are required to operate in parallel.

WIRING.

The greatest care has always been taken in wiring vessels of the United States Navy, and the standards of insulation and of work are of the very highest order. The student of electrical engineering can nowhere find a better example of a thoroughly high grade installation than on one of our ships. This excellence of work is, under the prevailing high wages and short working hours, obtainable only at a great expense as considered with the cost of foreign installations, but economy should not be sought in any changes involving the efficiency of the installation or the lowering of the standard of work.

The general system of wiring is to run two sets of circuits. One set called the "battle circuits" includes all lamps necessary in action. These circuits generally include all lights in fire and engine-rooms, coal bunkers and store-rooms below the protective

decks, lights not needed in action being turned off separately. On upper decks the battle lanterns are so placed as not to show from outboard. All exposed lights and all used for ordinary illumination are put on "the lighting circuits." On going to quarters all these lights are cut out at the switchboard in the dynamo-room, and there is no necessity for an inspection of the whole ship to determine if unauthorized lights are in operation.

To further insure proper lighting in action, the ends of the battle mains are interlocked at many places in the ship, and the circuits are kept as much as possible below the protective deck. This system becomes more important as the necessity for electrical energy in time of action increases, as it is doing daily by the extended use of electric motors.

The number of circuits at the switchboard has been decreased of late by the use of "feeders." These are heavy conductors leading from the dynamo-room to the general location to be lighted, where, by means of a "feeder junction box," they branch right and left into "mains." Each pair of mains may have a feeder box placed in it, allowing its division into two other pairs of mains. These feeder boxes contain no fuses, and the mains leading from them must therefore have a safe carrying capacity equal to that of the feeder fuses at the main switchboard. Switches may be interposed in the mains as desired, and in case the arrangement of the ship is such as to necessitate the use of many switches on the lighting circuits, it would be advisable to place the feeder boxes and switches together in sub-stations.

Subdivisions known as branch mains are taken off the mains by means of ordinary junction boxes, each of which contains a fuse. Branches may be taken from the branch mains in the same way. Ordinarily it is not intended that more than four lights shall be taken off one junction box, and the specifications call for an unbroken wire from the box to the lamp. All wires are enclosed in pine mouldings, there being at least three-quarters of an inch of wood between wires, and three-eighths between either wire and any metal connected with the ship. As a rule all fixtures are secured on wood, avoiding a heavy ground in case of low insulation resistance on the sockets or other metal parts. Of late, commercial ceiling fixtures, ceiling cut-outs, and non-watertight junction boxes have been installed in quarters where their use in

nowise impairs the insulation efficiency of the plant, with the idea of avoiding the expense and loss of light attendant on use of the standard water-tight fixtures. There is probably no case recorded of any report having been made complaining of too much light in any of the living spaces of a ship. The tendency is always to seek a brilliant illumination, and it is very poor economy to obtain light and then interpose heavy ground shades for the purpose of subduing it.

The search-light leads extend from the switchboard, directly to the projectors or to the control stands, being broken at intervals of about every fifty feet for convenience in installation, the ends being joined in search-light junction boxes which contain no side holes and no fuses, being used simply to avoid splices.

The standard wire is now without any lead covering. The latter was used as a waterproof covering to the insulation and as protection from mechanical injury. In neither of these two respects did it prove satisfactory. The spar-deck and engine-room circuits of several ships, wired with lead-covered wire, have had to be entirely renewed at the end of three years. On removing the old wire, it is found that the handling involved in getting it into place is very liable to break or dent the lead, admitting water to the insulation and retaining it. Any defect in the insulation will then cause a bad ground. The lead covering practically puts all grounds in parallel, and is, moreover, objectionable from its extra cost and weight. The new standard wire depends for its durability on the insulation being to a greater extent of vulcanized rubber, and on a heavy braid covering which is saturated with a waterproof compound. Sufficient mechanical protection is given by the moulding. The new wire is, of course, to a certain extent experimental, and if experience should show that it is inferior to wire of the same grade covered with lead, the latter might be again used.

In order to obtain the high insulation resistance called for in naval plants, great care is necessary in installation. The standard called for, of at least one megohm on each circuit, and 500,000 ohms on all in parallel, is intended to secure care in installation, and would be unobtainable in anything but dry weather, the surface conduction over socket shells and over exposed metal parts of the circuit being sufficient in ordinary weather to bring the in-

sulation far below that figure. The general precautions taken, in order to reach the limit, are the use of high insulation wire and the separation of all parts of the circuit from the metal of the ship by means of wood moulding, or by hard rubber tubing when passing through bulkheads and beams. Grounds frequently occur on the lamp sockets, which would be dead grounds if it were not for the interposition of wood.

The high insulation called for is not only a guarantee of good material and careful work, but also insures against accident.

With telephones, fire and water alarms, torpedo and gun circuits, helm and revolution indicators, and various kinds of call signals, all operated by electricity, high insulation of the dynamo circuits becomes a necessity, a cross between two wires involving many possibilities of trouble. An electric light system would probably operate perfectly well on an insulation of five hundred ohms, although there would be a greater risk of sudden break down aboard ship than would exist in shore plants. The specifications call for the best possible work in installation, as a guarantee of good operation and durability. Every care should be taken to localize and eliminate even light grounds. Nearly all the trouble is experienced on the fire-room and spar-deck circuits, and arises very largely from the water-tight fittings not being properly closed and screwed up, allowing damp air or water to get inside.

In laying out the wiring, the size of the wires is determined under three provisions of the specifications. One stipulates that no single conductor shall be smaller than number 16 B. W. G. The second calls for a cross section of one thousand circular mils (one square inch equals 1273236 circular mils) for each ampere of current at full load, authorizing a double current in search-light leads. The third calls for such a cross section that the fall in potential between the dynamo and the farthest lamp shall not be more than three per cent on full load.

In laying out a ship installation the calculations are made on the area of the conductors in circular mils. As stranded cables are used for all sizes above No. 14 B. W. G., results cannot be expressed in terms of diameter. The exact area required cannot always be obtained in stranded cables, and the nearest size admitting of convenient manufacture is therefore taken. The following are the sizes of conductors commonly used in the service :

No. 16 B. W. G.	4,225	circ. mils.
No. 14 "	6,889	"
20–30 B. W. G. flexible cord	2,880	"
7–22 B. & S. flexible cord	4,498	"
7–20 B. W. G.	8,575	"
7–18 B. & S.	11,368	"
7–19 B. W. G.	12,348	"
7–16 B. & S.	18,080	"
7–17 B. W. G.	23,548	"
7–16 "	29,575	"
7–15 "	36,288	"
19–18 "	45,619	"
19–17 "	63,916	"
19–16 "	80,275	"
37–18 "	88,837	"
37–17 "	124,468	"
37–16 "	156,325	"

The ruling condition of manufacture of stranded cables is that the cable must consist of 7, 19, 37 or 51 wires, if all are of equal size. By varying the size of each of the component wires, stranded cables of any desired cross section may be made.

The determination of the cross section of the mains is as follows: The maximum drop allowed is three per cent. on eighty volts or two and four-tenths volts:

$$\therefore 2.4 = \text{current} \times \text{resistance of mains.}$$

The resistance of a conductor of pure copper is commonly expressed by

$$R = \frac{\text{Length of conductors} \times 9.612\ (1 + at)}{\text{Area of conductor in circular mils}},$$

9.612 being the resistance in legal ohms at 0° Centigrade of a wire one foot long and one circular mil in area. Adopting 70° F. as an average temperature for wires on shipboard, this expression reduces to

$$R = \frac{\text{Length} \times 10.42}{\text{Area}}.$$

Although navy specifications call for pure copper wire, the twisting involved in making stranded conductors shortens the

cable from three to five per cent. and practically diminishes its conductivity to that extent. Introducing an allowance of four per cent., we have

$$R = \frac{\text{Length} \times 10.83}{\text{Area}}.$$

Substituting in the first formula and reducing we have

$$\text{Area in circular mils} = 4.5 \times LC,$$

L being the total length of wire in circuit in feet (both conductors) and C the current in amperes.

Making C unity and substituting 1000 circular mils, the corresponding area called for by the navy specifications, we obtain a value of L of 222 feet. For shorter lengths than this, the area calculated from drop alone would be less than allowed by the specifications for carrying capacity. We have, therefore, the simple rule: for mains extending to shorter distances than 111 feet from the dynamo, the area is determined by allowing one thousand circular mils per ampere; for greater distances, the area must be determined from the fall of potential alone by the above formula.

A useful modification of the formula is to determine the area of conductor for any given number of 16 candle-power lamps, each averaging about eight-tenths of an ampere. Substituting

$\frac{8N}{10}$ for C, N denoting number of lamps,

$$\text{Area} = 3.6 \times LN.$$

These formulæ apply, of course, only to navy standard lamps and to naval wiring specifications.

Most of the fittings in use aboard ship are figured in General Information Series, No. XI. A few others are shown in Figures 2 and 3. Figure 2 is a receptacle for search-light leads, being placed near the projector. Its use is not universal, as the leads may, in many cases, lead unbroken to the switch in the control stand or pedestal. Figure 3 shows the stuffing boxes used in carrying wires through water-tight bulkheads or decks. The small one is the ordinary bulkhead tube. The one on the left is for ordinary decks, the right hand one being for protective or other curved decks. The length is necessary to pass through the

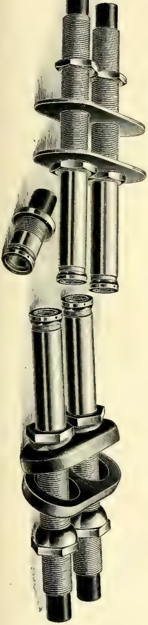


Fig. 3.

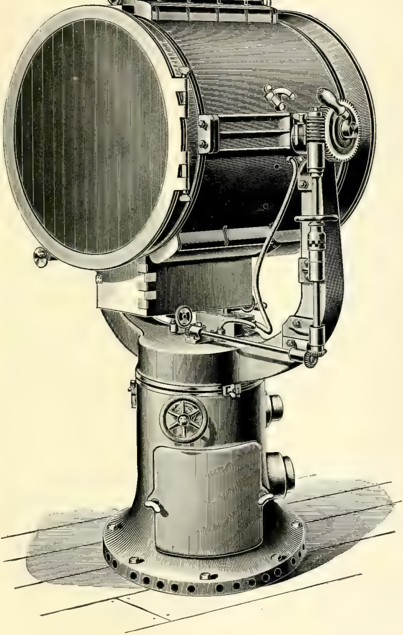


Fig. 4.

planking. All these tubes are of brass, lined with hard rubber tubing.

SEARCH-LIGHTS.

Several kinds of search-lights are now in use in the service. The Chicago, Atlanta, Boston, San Francisco and some others are fitted with apparatus of French manufacture; later cruisers received projectors made by the Thomson-Houston Co., while those finished within the last year are fitted with Thomson-Houston projectors of still another type.

The Mangin projector, as originally manufactured by Messrs. Sautter and Lemonnier, of Paris, was admirably designed and constructed for the conditions of use on shipboard, and but few improvements in the general plan have since been made. It is desirable to have the projectors used in our service of American manufacture, and the Thomson-Houston Electric Co. have, for several years, supplied good apparatus. The principal trouble has been with the mirrors, great difficulty having been experienced in making the silver permanently adherent to the glass. The manufacturers are now willing to guarantee the silvering, and greater durability is hoped for.

The latest type of projectors, illustrated in Fig. 4, are much larger and heavier than their predecessors, and in those respects are not improvements. They include, however, the new principle of electrical control, and the experience obtained with them will be of value. The apparatus is quite thoroughly explained in General Information Series, No. XI, June, 1892, and no further description is necessary.

It has been the practice for several years in the service to connect all search-lights in parallel, controlling each circuit from the switchboard, where they may all be thrown on a separate dynamo, or, if desired, may be worked from the same dynamo which is feeding the incandescent circuits. The former practice is generally followed, but is by no means necessary, as the damage done to the incandescent lamps by the sudden momentary changes of voltage, caused by the search-lights being thrown on or off, is more theoretical than real. The sudden jumps are of course unpleasant to the eye, and for this reason the use of a separate dynamo is preferable. In action, it is intended with plants of the

latest type to operate all dynamos in parallel, and the flickering of the incandescent lights in such circumstances is of no importance.

Each search-light has its own dead resistance. It has been argued, from economical considerations, that this resistance should be avoided by lowering the potential of the dynamo to that of the lamp, but it has been found that the resistance is of so much practical benefit in the operation of the lamp as to make economical considerations less important than those of good working.

In the operation of arc lights carrying the heavy currents now used, the simplicity of Ohm's law is widely departed from, and the sudden variations of resistance, due to the change of position of the arc or to impurities in the carbons, defy all permanent adjustments. Under these circumstances, the dead resistance acts somewhat like a buffer, diminishing the effect of the change and affording a working margin of potential. Any arc lamp operates to better advantage with dead resistance in circuit, and, this being the case, it is true economy to waste sufficient energy to secure good operation.

The best results with search-lights will always be obtained with the hand lamp. It requires but little attention from an operator to keep the crater in an inclined lamp well shaped and placed, but that little attention is necessary, and no automatic mechanism can take its place. The latest type of automatic lamp furnished our ships, shown in Fig. 5, works as well as any inclined lamp in use in other navies, but when the best results are desired must be controlled by hand. The two great difficulties that automatic action cannot control are the shifting of the crater into unfavorable positions and the "mushrooming" of the arc or building up of an obtuse point on the end of the negative carbon, which masks the crater. The operator adjusts the carbons to keep the crater turned full towards the mirror, and gets rid of the mushrooms by bringing the carbons together and breaking it off. In an automatic lamp the mushroom grows slowly, cutting off much of the crater radiation and causing the crater to form too near the end of the carbon. The arc adjusts itself to the potential for which the lamp is set, and may operate steadily under the conditions stated until the mushroom suddenly falls off, causing an immediate lengthening of the arc, which is generally attended with the extinction of the light.

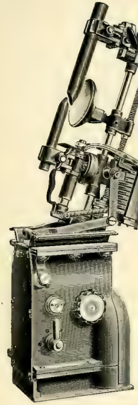


FIG. 5.

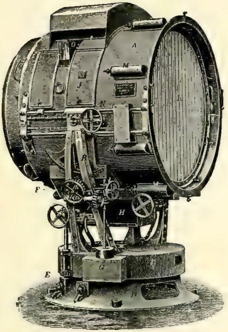


FIG. 7.

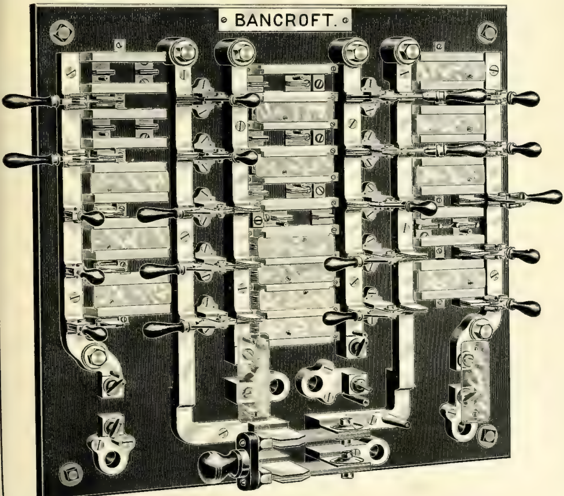


FIG. 8.

In spite of these difficulties there are certain advantages in the automatic lamp which recommend it, although no type should be used that cannot also be worked by hand. There are frequently cases where the search-light may be needed suddenly, as with a man overboard, vessels sighted, or danger reported by the lookout. Under these conditions it is a great convenience to have a lamp ready for operation by turning a switch.

The difficulties experienced with the inclined automatic lamp are largely overcome by placing the carbons in line horizontally in the axis of the projector, the crater of the positive being in the focus of the mirror. Left to itself in this position, the upper part of the crater is consumed by the flame of the arc which rises vertically, causing the crater to become inclined upward. This can be avoided in several ways, the simplest being to place a semi-circular bar of soft iron of about two inches radius below and at right angles to the arc and concentric with it. This iron becomes magnetized by the lines of force of the current, and reacts on the arc, keeping it down in place and preventing the deformation of the crater. The objection to the horizontal lamp is that the middle of the mirror is inoperative, the crater radiation being cut off by the negative carbon. The diameter of the latter cannot be reduced beyond a certain point, nor can the length of the arc be increased, so that considerable loss of reflecting surface is inevitable. Experiments have been made on horizontal lamps, resulting very favorably when working automatically, and it is probable that apparatus of this type may be issued to the service for trial.

The control of projectors from a distance by means of electricity has been tried in foreign services, and several of our ships will have this system installed. The New York has four thirty-inch projectors, all operated from the forward bridge. It has been claimed that a great advantage is gained by having the observer at a distance from the projector, as his eyes are not dazzled by the glare, and he may thus be capable of seeing faint objects which he might miss if nearer the light. For navigation purposes also, it might be a great advantage for an officer on the bridge to be able to throw the beam wherever he wishes without the delay or uncertainty involved in transmitting orders. The objections to the system are, however, serious. The first is the necessity for

having two commanding positions for each projector, as unless the beam of light can be thrown to any quarter and followed everywhere by the observer no advantage is gained. It is very difficult on most of our ships to obtain good positions for the projectors alone. The control stand must have some protection afforded from weather, and yet, if housed in, the view of the operator becomes restricted. If it is necessary for him to operate by commands received from another, the advantage of electrical control is lost, as the orders could be given with equal facility by word of mouth, voice tube, or telephone to an operator at the projector itself. The second objection to electrical control is in the complexity and weight of the mechanism. The weight of each projector and its accessories aboard the New York is about 1980 pounds, and although this will be reduced in future manufacture, the weight would probably be as great as that of two hand projectors occupying the positions of search-light and control stand. The control mechanism is complicated, liable to injury and difficult to repair with the facilities aboard ship, involving also considerable expense in installation.

It will have to be determined by experience whether the advantages of electrical control from a distance are sufficiently great to compensate for the increased expense and complexity, the extra weight involved, and the double space occupied.

In working the new type automatic lamps but few precautions are necessary. When used automatically, the lamp should always be left in good order after use, with a well formed crater, the carbons properly placed and in contact, and the spring adjusting the potential at proper tension. A good light will then be obtained in a few seconds after switching on the current. In working automatically, much better results will be obtained by having an operator in position to inspect the lamps and correct any fault that may cause a serious diminution of light. When working entirely by hand, the carbons can be brought into contact without risk of any injury to the dynamo, as the series magnet of the lamp immediately separates the carbons striking the arc. The carbons should not, of course, be held together when the current is on.

The Mangin projector was for many years unequalled in the power of the beam it produced. Many other kinds had been tried,

but none could compete with it successfully. The Mangin has the advantage of having both its surfaces sections of spheres, and the spherical curves greatly facilitate the process of grinding and polishing. The mirrors have considerable thickness, supplying the strength necessary in service. The principal disadvantage is the fact that the mirror subtends a small solid angle at the focus, and that much light is lost by falling on the projector barrel instead of on the glass. Recent mirrors have a shorter focal distance.

Parabolic mirrors furnish theoretically the simplest type for search-light use, but glass parabolas are difficult to construct, and metal reflectors are worthless from the rapid deterioration of the reflecting surfaces. Recently Schuckert, of Nuremburg, has succeeded in making parabolic glass mirrors with a sufficient degree of accuracy for search-light work, and has for several years supplied all used in the German Navy, besides furnishing a large number to other governments. The Schuckert mirror is a parabola, with its two surfaces parallel and silvered on the back, the thickness of the glass being only that necessary to provide strength, about four-tenths of an inch. It is easy to construct a parabola with any desired focal distance, while preserving the relative lightness of the mirror. The makers favor the use of a large mirror with a short projector, the standard size in the German Navy being ninety centimetres, the focal distance being either 35, 42 or 45 centimetres. The Schuckert lamp is of the horizontal type, the carbons being in line. The current in the navy 90-centimetre projector is either 120 or 150 amperes, with a difference of potential of 60 volts at the arc. The positive carbon is 38 millimetres in diameter, the negative 26, and the length of the arc about 18. The projector is fitted with double diverging lenses, by which the divergence of the beam may be varied at will, and is generally arranged for electrical control from a distance. The lamp can be operated either automatically or by hand.

It is to be hoped that the Schuckert projector may soon be given a practical trial in our navy, to determine its relative efficiency under service conditions when compared with the Mangin. Theoretically the parabolic mirror has decided advantages, but it is probable that these may be greatly modified by considerations of manufacture and use. The parabola is more difficult to grind and polish, and consequently costs more, while perhaps more liable to

mechanical defects than the Mangin form. The mirror is most satisfactory when large, but must then be thin to reduce the weight, and is thus rendered more liable to injury. These points could, however, be waived if it were conclusively shown that the Schuckert projector was more powerful and equally well constructed.

Avoiding any theoretical discussion, it is necessary here to only illustrate the difference between the mirrors, leaving all questions of utility to be determined by trial. Figure 6 shows two mirrors of the same diameter, one Mangin and the other Schuckert, the focal distance of the former being twice that of the latter. A horizontal lamp is used and the radii of the curves show the intensity of the light on each angle. As drawn, the parabolic mirror *P* practically receives all the light radiated from the arc, while much less falls on the Mangin mirror *M*. In order to make the latter effective it must be brought nearer to the focus, but as there is always a fixed relation between the radii of curvatures of the Mangin mirror, the refractive index of its glass, and the focal distance, the latter can be varied only within limits without sacrificing the desired concentration of light. The Schuckert mirror, on the contrary, can be made with any desired focal length, the concentration becoming only slightly less as the focal distance is decreased.

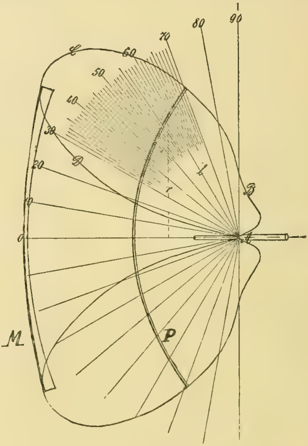


FIG. 6.

The limit is found in the practical considerations of leaving room for the negative carbon of the lamp, and of not overheating the mirror. In practice the 90-centimetre Schuckert projector, using a current of 120 to 150 amperes, has about the same focal distance as the 60-centimetre Mangin, using 75 to 90 amperes. The solid angle, subtended by the mirror at the arc, is always greater with the parabolic form, and other things being equal, the amount of light reflected is greater.

Another point already alluded to, on which practical tests are very desirable, is the relative efficiencies of inclined and horizontal lamps under service conditions. The latter seem to offer great advantages for automatic use, as the action of the lamp is better and the movement of the crater on the positive carbon less when the carbons are in line than when they are displaced, as in the inclined lamp. The artificiality of the latter arrangement almost precludes any automatic working. If the horizontal lamp is used it gives the parabolic mirror another advantage, as the focal distance of the Mangin mirror is comparatively so great that much of the surface is in the shade of the negative carbon and is useless as a reflector.

Figure 7 shows the type of electrically controlled 90-centimetre projector in common use in the German Navy. In the latest type there is less gearing, and most of it is concealed in the base.

There is probably no question of naval outfit in a more unsettled condition than that of the utility of search-lights. It may safely be said that most officers think they are more trouble than they are worth, and yet when a decision must be made, few, if any, would advocate their abolition. The fact that they are retained in every principal navy in the world is proof that they are thought to be a necessity. The uncertainty as to their advantages is probably very largely due to the fact that officers obtain but little experience in their use as military weapons. The weekly practice is generally confined more to a test of the actual condition of the apparatus than to solving any of the tactical questions involved.

Lieutenant Bacon, an experienced torpedo officer of the British Navy, in a short article published after the manœuvres of 1892, stated the conditions underlying search-light work with exceptional clearness, and no better presentation of the subject can be made than in his own words:

"Objects on the water or against the horizon are visible solely by the contrast of their color or shade with that of their surroundings. Were the object exactly similar to its surroundings, naturally it would appear but as part of them and be invisible. In bright sunshine it is impossible to imitate water so exactly in its varying color and shades as to render a boat absolutely invisible upon it; so much light is always present ready to be reflected from all parts of an object that slight variations are easily detected, but at night this is different. Smooth water at night, when lit up by a search-light, appears very dark indeed, and naturally so, since to an observer near a projector but few rays are reflected back from the small ripples; the water, therefore, appears almost black. Now place on this an object which also reflects but little light to the observer, such as a 'dead' black boat (one painted with black lead), and the contrast between the two is almost *nil*; in fact, so nearly may the two sets of reflected rays match one another as to leave the boat, though in the centre of the beam, practically invisible from the ship. It is not sufficient to merely let the beam fall on the boat, but to see it, it is necessary to produce a distinct difference between the light reflected by the boat and that reflected by the water. This at once explains a very common occurrence to all who have taken part in night attacks—that is, to find your boat brilliantly lighted by a search-light beam, and yet for the beam to pass by harmlessly without the boat being observed by the ship. Nor is this all. Observers on board the ship are, to a certain extent, dazzled by the brilliancy of the beam even when at some considerable lateral distance, since the particles of moisture or dust in the air reflect and diffuse light to a considerable extent, and an effect is produced similar, but, of course, to a less extent, to looking out of a light room into a dark night; the exact extent of the effect is determined by the angular position of the observer from the projector and object. There is yet another effect that limits the distinct vision of an observer near a projector, and that is the fact that when near a projector the rays reflected from an object have to travel back for some distance through the beam—that is, they suffer from considerable interference. The result is that the object appears indistinct. It will be easily seen that all these effects greatly reduce the efficient use of a search-light when used to pick up an

object if the observer is placed near the projector, as is usually the case on board ship, especially when the object is traveling towards the ship at a high speed. The practical proof of this is shown by the fact that a boat is rarely itself recognized in the first instance at any great distance, but originally attention is attracted to her by her bow wave—that is, the wave of foam, which reflects a comparatively large amount of light and shows up distinctively against the surrounding dark-colored water.

"Were the above case, viz., that of detecting boats from a ship by means of a search-light in the ship the sole use of that weapon, it might, indeed, be an open question whether the electric beam is any material good in naval warfare, for there is one point which must never be forgotten, and that is that the fact of burnning such a light reveals the position of the ship to an attacking boat, when, by an absence of all lights, the darkness of the night might be a more efficient protection. It is this particular case which is the one that correspondents in manœuvres are most frequently brought into contact with, and on it opinion is so much divided that in open water it is probable that no captain would promiscuously use his search-light as a method of defense. Happily, however, other occasions arise in war time when the search-light is of great value. These may be divided roughly under two heads: (1) Defense of a fleet in close waters, where the position of the anchorage water of itself reveals the probable position of the fleet; (2) Fleet action at night, or action between single ships.

"Regarding (1) the case may be briefly stated as follows: Ships are at anchor in a close anchorage for some particular reason, either for repairing or refitting purposes, or else the close presence of a superior force. For it is inconceivable, considering the deadly nature of a torpedo-boat attack, that an officer would keep his fleet at anchor at night in a harbor that afforded by its position a possibility of an attack from torpedo-boats if he could possibly avoid it. Supposing such the case, the search-light may be a most efficient help against such an attack. Light may be burned at a distance from the ship on shore to light up the entrance or different sections of the passages through which the torpedo-boats will have to pass, or the ships may illuminate the passages and use observers in their guard-boats. In either case the effect is the same, for no longer has the light reflected from the attacking boats to be reflected

at a small angle to the observer, but the observer is placed in a far better position as regards reflection, and far more minute differences in shade can be observed, since the reflected light is much greater. In other words, a greater contrast is produced between non-reflecting bodies, and the water gun-fire can, therefore, be more effectively used and greater havoc effected on the attacking force. In such a case one thing is certain—for detecting boats, all beams must be fixed so that observers may get their eyes accustomed to a constant intensity of light, and not a variable one, as produced by 'sweeping' beams. This is the most effective use of an electric search-light. A few beams may, of course, be kept in reserve for following up and illuminating boats after they have been detected, but these should be quite independent of the fixed beams. The guard-boats, some two thousand yards away, can see the approach of others several hundred yards off, since the surrounding water is well illuminated by the beams of light playing on it. When the boats are discovered, it is necessary to light them up sufficiently for the guns' crews in the ships or boats to use their guns. This may be done by the ships' projectors with divergent lenses in conjunction with parallel beams, the divergent lenses being used to light the boats up, and from their large divergence prevent the chance of losing sight of them again, and the parallel beams to more brightly illuminate them and make them more clear to the guns' crews.

"Again, in single ship or fleet action at night search-lights must be used to light up the enemy, and now the search-light is no longer an objection as showing the position of the ship, since its height prevents an accurate estimation of the position of the waterline (the most vulnerable position in the ship to fire at), but in reality it is absolutely safeguard, both since it is misleading as to the distance of the ship and also is blinding to the opposing guns' crews. From the foregoing remarks it will be seen that the function of the search-light may be either to discover or to light up an object for guns to fire at. These two different uses are important, since they lead to the height of the light being varied to some considerable extent. It has long been the opinion that for discovering boats the beam should be low, since its direction is parallel to the surface of the water, and therefore lights up a larger area than would be the case if thrown down on the water from a

height, when the plane of the water would cut the beam in an ellipse, whose area depends on the inclination of the beam. But a little thought will show that if the beam be parallel to the water the water is but feebly illuminated, whereas a body vertical to the water cuts the beam at right angles and receives a large amount of light. Were the body absolutely non-reflecting, it would be invisible ; but if reflecting, a contrast will be obtained. Now that boats can be painted so as to be practically non-reflecting, the low beam is viewed with more disfavor, especially as detection is not the chief function of a light in a ship. The real function of the light on board is to light up an object whose approach has been detected, so that the guns' crews can accurately lay their guns. To do this, it is necessary to keep the light as far from the guns as possible, and also to keep the beam off the water near the ship, so as to prevent the men being dazzled. The best position in the case would appear to be, to have the light above the guns, so that the crews practically do not see the beam, except where it strikes the object, and also should the opposing ship use the light to aim at, the shot will be more likely to pass over the ship. Another great point is to have the projectors so placed as not to illuminate any portion of the side or superstructure of the ship ; this, again, is best obtained by a fairly high position of the light.

"For attacking forts or in action in moderately smooth water, a light in the military tops would seem to answer these requirements ; but, of course, with even a moderate motion of the ship a beam from a projector so placed would sweep through a far larger arc than one in a lower position, and would, therefore, be far harder to keep steadily illuminating an object. For navigating purposes, where the water close to and for some distance ahead of the ship has to be illuminated, a low position of the light is best."

A brief consideration of the preceding is enough to show that much of the uncertainty existing in the minds of our officers as to the value of search-lights is due to the fact that no experiments are made to test the conditions of their efficiency or to develop proper methods of utilizing them. The search-light is a weapon of offense as well as of defense, and requires more judgment and skill in its control than any other weapon entering into the military equipment of a ship. If used at the wrong time it may lead

to the destruction of the ship by betraying the exact position to a powerful enemy; if used properly it may save the vessel by depriving an attack of the darkness necessary for its success. Nothing but practice under conditions as nearly as possible simulating those of warfare can give officers clear opinions of how the search-light enters into the fighting power of the vessel. Weekly practices may develop interesting electrical facts as to the light obtainable from heavy currents, but these can be carried on as well from a wharf as from a ship's deck. The many tactical questions, such as how to use the search-lights under different conditions of the atmosphere or of the sea; how to utilize them in case of a vessel at anchor in a harbor; how when lying in an open roadstead; the advantages obtainable by dazzling an enemy and preventing his sighting his gun; the best way of avoiding detection by a search-light; the best method of stationing observers; the practical advantages or disadvantages of electrical and hand control for projectors; the utility of diverging lenses; and, above all, the conditions under which search-lights should *not* be used, are all matters of the greatest importance, concerning which but few officers have opinions based on experience. A practical investigation of these mooted points is possible aboard almost any ship in commission, and a course of experimental drills would be most valuable in the practical information it would develop.

STANDARD SWITCHBOARD.

The specifications for the system of switchboard connections have gradually been growing more complex from year to year. In the specifications for the Columbia and Olympia they read, "the design to be such that the dynamos may be run either singly or in multiple on the incandescent circuits, either singly or in multiple on the arc light circuits, and either singly or in multiple on the arc and incandescent circuits connected in parallel." The standard switchboard was devised to meet these specifications without taking up valuable space.

The switchboard has been briefly described in General Information Series, No. XI., but further details may be advisable. The system is the same, whatever may be the number of circuits or dynamos installed, so that a person familiar with it can operate the switchboard at first sight.

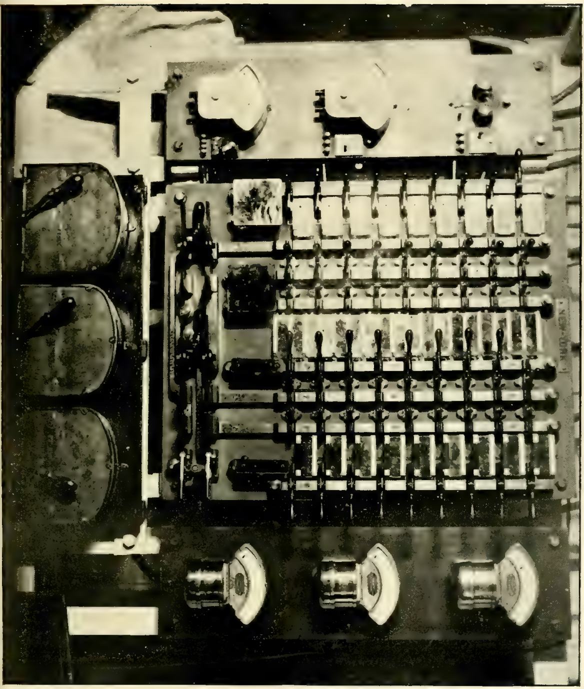


Figure 8 is the switchboard of the Bancroft arranged for two dynamos and ten branch circuits, and shows the most symmetrical and simplest arrangement. Figure 9 illustrates the switchboard for three dynamos and eighteen branch circuits. The board has on each of its edges a vertical bus bar fitted with fuse clamps and terminals at the lower ends, the two bars being connected by a cable on the back of the board. The bus bar thus formed is common to all the dynamos, and in practice is connected to the positive terminals. Inside of this bar are the fuses on the positive ends of the branch circuits. On each side of the centre of the board there is a set of vertical bars, each set containing as many bars as there are dynamos. The similarly situated bars of each set, counting from the left as number one, are connected together by a cable on the back of the board, forming the negative bus bar of the same dynamo. Between the two sets of negative bars are the negative branch circuit fuses.

One-half of the branch circuits are placed on each side of the vertical center line. The positive terminal of each is in the clip near the common bus bar, in which the switch shown in the figure engages. The negative end of the circuit is in the socket, in which fits the shifting plug switch near the center of the board. One of these sockets is placed between each two of the negative bus bars. The plug switch has two small bosses on each side which serve to clamp it in the socket in the open position at right angle to the face of the board. By withdrawing the plug slightly the bosses are disengaged, and the switch may then be thrown to right or left, connecting its circuit to either one of the dynamo bus bars between which it is placed. In a board designed for three or four dynamos the plug switch may be shifted from one socket to another so as to be placed in position to connect its circuit to any bus bars.

The switches for connecting the dynamos in parallel are at the bottom of the board. They are double pole, the upper half connecting the negative bus bars, while the lower half connects the two equalizing bars. The board for two dynamos has only one multiple switch, but those for three or four dynamos have a switch for each dynamo. In the latter case, the upper half of the switch connects the negative bus bar of its dynamo to a common negative bus bar, while the lower connects the equalizing bar of the same

dynamo to a common equalizer. It is then necessary to close two switches to connect two dynamos in multiple, the connection not being complete until the last switch is closed. When two or more dynamos are operating singly the multiple switches are open, and hard rubber guards are placed in the clips to prevent any accidental closing.

As one pole of each dynamo is connected to a common bus bar it can be entirely cut out of circuit only by a double pole switch on the headboard of the dynamo. This switch is therefore a necessity when the standard switchboard is used, and should always be open when the dynamo is not in operation.

All connections are made on the back of the board. Each conductor is soldered to a conical copper plug. The end of this plug has a screw thread tapped in it, and fits into a corresponding conical socket in the bus bar or fuse terminal, being secured in place by a screw inserted from the front of the board. When this is screwed up, it makes a good and reliable contact.

The design of the switchboard is very simple. All vertical lines are dynamo circuits, all horizontal ones branch circuits, the plug switches being at the intersections. The following directions are from the official instructions :

1. No metal, such as screw-drivers, monkey-wrenches or other tools or watch-chains, should be allowed near the front of the board. Any neglect of this kind may cause dead short-circuits.

2. Putting more than one plug switch on any one section is positively forbidden, as the use of two might put dynamos in parallel without any equalizing bar.

3. If any section is not wired up, it is advisable to remove its plug switch entirely.

4. In throwing a section in circuit it is advisable to first place the plug switch in proper position for putting the section on the dynamo desired, and then close the switch on the common bus bar. In cutting out a section, first open the common bus bar switch and then the plug switch. In changing a section from one dynamo to another, it is best to first break the circuit with the common switch, then throw the plug switch over into proper position and close the common switch. The plug switches are not intended for throw-over switches.

5. When any section is wired up, but not in circuit, its common switch should be open, and its plug switch open and locked.

6. When the dynamos are operating singly the multiple switches should be open and the spring clips covered by hard-rubber covers. These covers to be removed before attempting to connect in parallel.

The standard arrangement of switch and instrument boards is shown in Figure 9. The left hand instrument board carries at the top a ground detector fitted with a multi-throw switch, having as many contacts as there are dynamos. By connecting this with one of the negative bus bars, starting the corresponding dynamo and throwing any plug switches on the same bus bar, each and all branch circuits can be tested for grounds, or an existing ground may be speedily localized. On the middle of the board is a vertical reading Weston voltmeter. One of its terminals is connected to the common bus bar, the other to a multi-throw switch by which it can be put in connection with any one of the negative bus bars. By moving this switch, the potential of any one of the dynamos may be measured and the polarity also tested, the voltmeter needle showing the direction of the current in the instrument. This voltmeter is always kept in circuit and can be read from a distance. The lower voltmeter is connected so as to give the difference of potential at the terminals of the search-lights, having a multi-throw switch with as many contacts as there are projectors. It is identical with the other voltmeter, and is in reserve in case of accident. As its use on the search-lights is unimportant in case of electrical control projectors, it may be used for other purposes.

Underneath the switchboard are the shunt field rheostats, the left hand being in circuit of the dynamo connected to the left hand bus bar, which in turn is connected to the left terminal of the voltmeter multi-throw switch. The instrument board on the right of the switchboard carries the ammeters, one being in circuit of each dynamo. It is highly desirable that the same system of connections should be followed on all switchboards, to enable persons familiar with one plant to take charge of another at sight. The system shown in Plate I. has therefore been approved by the Bureau of Equipment. It is, that the same sequence should always be followed from left to right on the negative bus bars, voltmeter terminals and shunt field rheostats, and from top to bottom on the ammeter board. Thus number one dynamo would have the left

hand bus bar, left hand voltmeter terminal, left hand rheostat and upper ammeter ; number two dynamo would have the second bus bar, voltmeter terminal and rheostat, counting from the left and second ammeter from the top. A stranger, then, on entering a dynamo-room could by a glance at the ammeters see which dynamos were carrying load; the switches on the common bus bar indicate what branch circuits are in operation, while the position of the corresponding plug switches shows to which dynamo each branch circuit is connected. Finally, the multiple switches would show whether the dynamos were operating singly or in parallel, and if the dynamos were numbered, the whole situation could be grasped in a few seconds, and the stranger could operate the plant. At present many ships have switchboards which can hardly be understood with the assistance of plans, and no two are identical.

An examination of Fig. 8 shows that the condition of the Bancroft's circuits is as follows, neglecting the fact of the absence of fuses. Commencing at the top and numbering the left hand circuits from 1 to 5 and the right hand from 6 to 10, we have circuits 3, 4, 5, 9 and 10 on number one dynamo; circuits 6 and 7 on number two dynamo; circuits 1, 2 and 8 open; both dynamos operating in parallel.

The operation of compound dynamos in parallel seems to be practically confined to the United States, where it is almost universal in all large power stations. The difficulty encountered in operating in parallel is, that any inequality between the electromotive force of the two dynamos results in the one of higher potential reversing the series field of the other, and driving it as a motor. This is evident, from Fig. 10, any current from the upper dynamo to the lower passing through the series coil of the latter in the direction opposite to that of normal excitation. The series field would therefore be reversed. This trouble is easily removed by con-

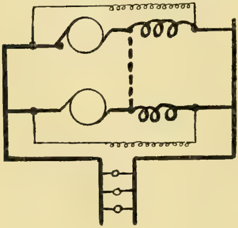


FIG. 10.

necting the brushes of the two dynamos by a conductor of *very low resistance* called an equalizer, as shown by the heavy dotted line. If, then, the electromotive force of one dynamo becomes higher than that of the other, current flows through the equalizer and through the series field of the weaker dynamo in the right direction, strengthening it and raising the potential. The vital point of safety in the system is to have the resistance of the equalizer so small that the greater part of the current may flow through it from brush to brush, instead of in the parallel circuit formed by the series fields and the mains. The operation is most successful when the dynamos are similar, but this is by no means essential, dynamos having been operated in parallel whose normal outputs were in the ratio of thirty-eight to one. The presence of the rheostat in the shunt field is of the greatest assistance. The ammeters are connected on that side of the circuit opposite the equalizing bar, so as to show the total current passing in the external circuit. If, then, one shows very much higher than the others, it is probable that it is feeding them through the equalizer. A slight adjustment of its rheostat weakens the shunt field, and by reducing the voltage of the stronger dynamo brings all nearer equality. The attendant can, therefore, by an inspection of the ammeters and adjustment of shunt rheostats make each one of the dynamos take its proper proportion of the load, although they differ widely in size, speed, type and output.

The following directions are given for connecting dynamos in parallel on the standard switchboard:

"In throwing dynamos in parallel care will be taken to see that each machine is poled right and kept on open circuit until the normal potential is reached before being thrown into circuit. The operation of throwing dynamos in parallel with the naval standard switchboard is as follows: Each dynamo must first be tested separately. It is brought to the proper potential of 80 volts in light load by adjusting the shunt field rheostat. Full load is then thrown on and the voltage should remain the same. If not, it should be adjusted to give the proper voltage by the shunt to the series field. This adjustment should be once made and occasionally verified; too much care cannot be given to it, and once adjusted should not be tampered with. With loads on each dynamo practically the same, and the difference of their potentials

less than one volt, the multiple switch may safely be closed and the dynamos will work together. Any inequality of load between them may then be rectified by the shunt field rheostats. The polarity of the dynamos will be shown by these measurements, and, as has been said, should be the same. When one dynamo is to be thrown in parallel with another actually working, it may be advisable to divide the load about equally between them, repeating the observations as to potential before throwing them in parallel."

In explanation of these directions, the polarity of the dynamos is shown by putting the voltmeter first on one and then on the other. The needle should indicate the same voltage on each. If it moves in opposite directions, one dynamo is reversed. Great care should be taken in connecting up the leads and equalizers the first time, to get everything in the right place. Once permanently connected right, no error could ensue except from a reversal of one of the dynamos, and this is shown on the voltmeter. In ships in which the dynamos are frequently operated in parallel, it might be well to connect the lower voltmeter on the instrument board to the equalizers instead of to the search-lights, especially if the latter have individual control stands. In this case, one terminal of the voltmeter would be connected to the common equalizer, and the contacts on the multi-throw switch to the individual dynamo equalizers. The switch should not be closed if there is more than one or two volts difference between the two equalizer sides.

In order to secure good working with the standard switchboards the equalizers from the dynamos must be large. A safe working rule would probably be to make them of the same cross-section as the dynamo leads.

The standard switchboard for three dynamos is shown in Plate I. with all its connections, made as authorized by the Bureau of Equipment.

MOTORS.

In General Information Series, No. VII., June, 1888, the writer dwelt at some length upon the advantages attendant on the use of the electric motor on shipboard. Since that time they have been largely introduced in different navies for hoisting ammunition or for training light guns, as well as for ventilation purposes. It is

unquestionable that they will come into more extended use for these purposes as well as for others, but a wise policy will limit their use to position, in which they are actually superior to any other type of machine. Thus, it would probably be inadvisable to place electric motors anywhere in the engine or fire-rooms, as the combined heat and moisture would cause speedy deterioration, and in such locations, moreover, the presence of steam-pipes is no objection. One of the most promising immediate applications of the electric motor is in the operation of ventilating fans, and this problem is now under consideration. The presence of steam-pipes always carrying live steam is a nuisance on a berth-deck, directly affecting the health and comfort of the whole crew. In some of the very best and latest ships of the Navy, however, the ventilating fans are placed on the berth-deck and are driven by steam engines supplied with steam through long leads of pipe. This method heats the living space of the crew more than it cools it. From a military point of view it is vitally weak, the whole or a greater part of the ventilating piping, on which the fighting parts of the ship must depend for air in action, being wholly unprotected against machine-gun fire which would riddle the pipes, utterly destroying the ventilation system. In some ships, moreover, immense air ducts are carried through the coal bunkers, displacing a hundred or more tons of coal and cutting up the remaining space so as to greatly interfere with coal passing. Nor can it be considered good policy to cut holes two or three feet in diameter in water-tight bulkheads, even if they are protected by automatic valves. The system thus outlined seems to interfere with both the military efficiency and the sanitary well-being of the ship. If it were necessary it could be tolerated, but every objection noted can be overcome by the use of electric motors, with a probable gain also in efficiency and weight. The general method will be outlined only.

The system would be to ventilate each compartment between main water-tight bulkheads independently, placing in each two small electric ventilating blowers. These could be used as either exhaust or supply at will. The advantage of placing the blower in the compartment to be ventilated is that no injury to the piping above can cut off the supply of air, as air now *enters* through any holes in the pipes instead of escaping. A general feed pipe might run fore and aft on each side of the berth-deck, from which all vertical

pipes leading to lower deck compartments could lead, the feed pipe being connected to the outer air by ventilators placed where convenient. This method prevents heating of the ship by steam fans, saves water-tight bulkheads and coal bunkers for their legitimate uses, secures ventilation of magazines and fighting spaces in action, and would probably be fully as efficient both in actual ventilation and in the energy required to produce it. It cannot be carried out with steam fans, the necessary net work of hot pipes heating the ship beyond endurance, but the electric motor will work in any place in which it can be set up, and neither in itself nor in its connections gives off any perceptible amount of heat.

Fig. 11 shows two ventilating fans operated by electric motors, supplied by the General Electric Co. for the Oregon. The motors are ironclad, the coils being wholly enclosed. A few slight changes were recommended in construction, but the general operation was very satisfactory.

One motor was connected to a Sturtevant exhauster No. 3, the the whole set weighing 254 pounds and supplied 1320 cubic feet of air per minute at the nozzle, at a speed of 1520 revolutions. The energy consumed was 10½ amperes at 80 volts, or 840 watts.

The other motor was connected to a Sturtevant exhauster No. 4, the whole set weighing 446 pounds. It supplied 2050 cubic feet of air per minute at the nozzle, at a speed of 1540 revolutions per minute, taking 21 amperes at 80 volts, or 1680 watts.

Both motors were series wound and started without any starting rheostat. The speed of the motors would, of course, be higher and the delivery of air smaller if piping was connected to the exhauster.

If problems presenting themselves in naval construction are impartially considered, it will be found that the electric motor has an unquestionable field of usefulness on shipboard. Much conservatism has been felt in relation to the use of untried or experimental machinery, but the electric motor can no longer be thus classed. Its widely extended use during the last few years, and the durability and general good working it shows under most unfavorable conditions in shore practice, are guarantees that it can be made reliable on shipboard.

It may not be amiss to consider the subject in the light of our necessities.

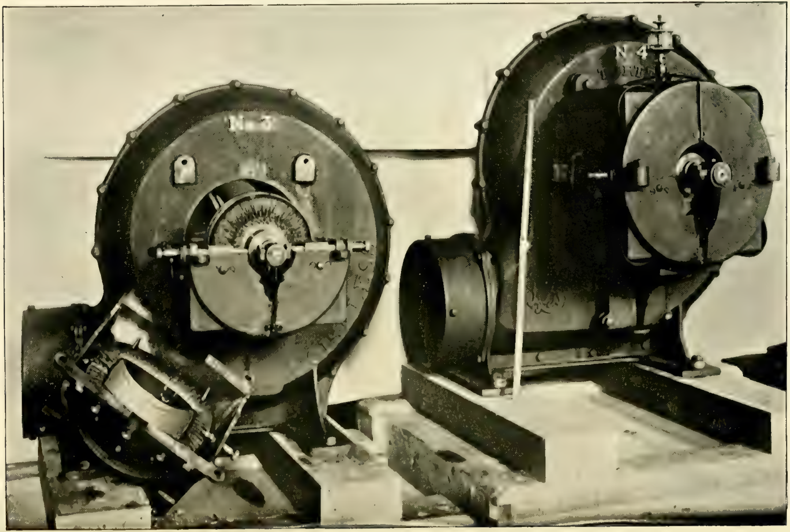


FIG. 11.

All motors on shipboard will naturally fall under the head of constant potential motors, supplied from the ship's mains, and either series, shunt or compound motors may be used. The series motor is valuable for its great starting torque, but has the disadvantage of an irregular speed. In many cases, as in training guns or in other heavy work, steady speed is of no consequence, while the ability to start with a heavy load is all essential. For work of this kind the series motor is the best. If thrown in circuit directly across the mains, it might burn out, the resistance being so low as to allow of an enormous current passing when the motor is at rest. As soon as it commences to move, the current is reduced to safe limits by the counter electromotive force. It is advisable, however, to interpose some resistance to save the motor, this being generally in a starting rheostat, the speed of rotation when once in motion being similarly controlled by resistances. An objection to the series motor is the fact that the speed rises dangerously high if the load is thrown off, the excitation being diminished by the rise of the counter-electromotive force of the motor. The motor makes the vain attempt to attain a speed at which its counter-electromotive force equals the difference of potential of the mains, each increase of speed diminishing the field current and counter-electromotive force and calling for higher speed to attain the voltage of the mains. Theoretically the speed of the series motor under such circumstances is infinite, but the practical limit is found in the fact that friction and internal losses always make something of a load, so that no motor ever runs absolutely light.

The shunt motor, when made with low armature resistance, preserves a practically constant speed with wide variations of load. It possesses, however, the great defect of having no starting torque. The field coils and armature being in parallel, the former are short-circuited by the latter, and if the motor is suddenly thrown into circuit, the field would not receive enough current to magnetize it, while the armature would probably be burned out by the excess of current passing. Some special starting device is therefore necessary, and a starting rheostat is commonly provided, by which a current is passed through the field coils before the armature circuit is closed at all. The next step is to send the current through the armature in series with a resistance, the latter

being gradually cut out as the counter electromotive force rises from the speed increasing. The special purpose for which the shunt motor is adapted is, therefore, starting with a light load and afterwards preserving an approximately constant speed. The starting rheostat is necessary and is objectionable as an extra fitting. There have been many cases in the service where these rheostats have been used in continuous running to diminish the speed of the motor, but not being designed for this purpose they overheat and finally burn out.

The apparent paradox, that the speed of a motor is increased by weakening the field and consequently the counter electromotive force, must always be borne in mind in considering the speed of motors. The fact that the shunt field remains excited when all load is thrown off, keeps the speed down to near its normal value. If the speed could increase, the field being kept constant, the counter-electromotive force of the armature would rise until it reached the potential of the mains. It could, of course, go no higher without running the generator as a motor. The actual limit attained is less than that of the mains, as there is always internal loss and mechanical friction in the motor, energy to overcome which must be derived from the mains, and the speed settles at such a point as to allow the motor to receive just this amount of energy.

As the compound dynamo preserves a constant voltage at its terminals with constant speed but varying output, the reversibility of the dynamo and motor would lead us to expect that a motor wound with both series and shunt coils on its field magnets would preserve a constant speed at constant potential with varying load, and such, within limits, is found to be the case. An important difference must, however, be considered. In the compound dynamo, the magnetic effect of the series coil is to reinforce that of the shunt, but if the compound dynamo is used as a motor the series coil will be found to act in opposition to the shunt. While this assists materially in preserving the speed constant when once established, difficulty is found in starting the series coil, which is practically the only one operative when the motor is suddenly thrown into circuit, and tends to start the rotation in the wrong way. As the shunt field "builds" it acts in opposition to the series, and this tendency to rotation in the wrong direction is overcome. It

will readily be understood that under such conditions the motor can have no starting torque, and if heavily loaded will burn out. This difficulty may be overcome by *reversing* the series coil, making it co-operate with the shunt coil. This arrangement gives powerful starting torque, and prevents the speed from rising too high when the load is thrown off, but the constant speed is sacrificed, although the variation may be so small as to be unimportant.

The compound wound motor, with both its coils acting in the same direction, possesses therefore the best points of both series and shunt motors, and is advantageous where starting torque and fairly uniform speed are desired, and especially where there is a probability that all load may be thrown off suddenly. If constant working speed is essential, the series and shunt coils must act differentially, the motor being either started light and load thrown on after speed had been attained, or the series coil reversed, as already explained, to gain starting torque, and thrown in differentially as soon as the motor reaches normal speed. This system is complex, requiring an external control board, but answers admirably in such cases as in operating lathes, where constant speed is essential.

The foregoing is sufficient to enable a conclusion to be reached as to the use of motors on shipboard. If starting torque is essential and constant speed is unnecessary, the series motor is the best, an adjustable resistance being inserted as a protection on starting. For purposes calling for constant speed the shunt motor is best adapted, having a rheostat for use only in starting. In special cases the double wound motor, possessing in a lesser degree the advantages of each of the others, may be best, but it is noticeable that its complexity is preventing its wide use in commercial practice.

A writer in General Information Series, No. VIII., in referring to the use of motors on shipboard, dwells at some length on the disadvantages arising from the increase of dynamo plant, and also on the danger resulting from having all the auxiliary motive power of the ship dependent on the dynamo-room. These objections must be considered in any scheme of electrical power transmission on shipboard. The following general plan is suggested for consideration. Electric motors will be advantageous,—

1. In all places where auxiliary engines operate continuously for extended periods, the steam and exhaust pipes necessarily passing through store-rooms or living spaces.

2. For ordnance purposes, where the demands for power are not excessive.

3. In isolated places such as military tops where power is necessary.

Electric motors are inadvisable :

1. In engine or fire-rooms, where steam is always available, and the conditions are unfavorable for the durability of motors.

2. In general, where the demands for power are excessive and steam is available, as in the windlass engine.

3. Where rapid and frequent reversals are necessary, as in the steering engine.

The question of safety of the dynamo plant can be met only by taking all precautions for the protection of the dynamos and wiring, and by operating the dynamos in parallel with a large reserve of power. If the development of ordnance applications of electric motors should become of great importance, a further guarantee of safety should be obtained by dividing the dynamos between two widely removed dynamo rooms.

COMPARISON OF SPECIFICATIONS.

Not only are different types of dynamo used in different navies, but the methods of operating the plant also vary. In nearly every service the voltage is now standardized at eighty volts, this being a compromise between the high voltage desirable for incandescent lamps, and the heavy demands for current made by the search-lights. In any case, the type of dynamo and engine actually adopted depends entirely on the specifications to be met. Although those of European navies are not widely published like our own, they are all in print, and no confidences will be betrayed by referring to them.

The British specifications dwell largely on the heating of the dynamo. The common provision is that "at the end of a six hours' trial at full load, and one minute after stopping, no accessible part of the armature or magnets shall have a temperature more than 30° Fahrenheit above the temperature of the dynamo-room taken on the side of the dynamo remote from the engine and three feet distant from it, and that the maximum rise of the temperature of the armature at the end of the trial shall not exceed the temperature of the dynamo-room more than 70° Fahrenheit." The word-

ing of these specifications is somewhat peculiar, and the first proviso seems to be utterly inconsequential, as the vital question is certainly not what the temperature is "one minute after stopping," but rather what it is while the dynamo is in operation. The temperature shown by a thermometer in one minute depends as much on the thermometer as on the actual temperature of the hot body, and with the latter remaining the same, the thermometer indications vary with the instruments used. The second proviso limiting the maximum temperature of the armature to 70° above the air is definite and intelligible. It is urged that the armature is hotter just after stopping than when in operation on account of the absence of cooling by the fanning of the air, but as the generation of heat ceases when the dynamo stops, it is difficult to imagine any rise of temperature. Most of the British dynamos have large flat field coils, and in case any curiosity exists as to the temperature of the field coils while in operation, instead of "one minute after stopping," it can be determined with considerable accuracy by having thermometers strapped on the coils throughout the test, covering the bulbs with waste or flannel. The armature temperature must be determined in the same way after stopping, no other method being available. The following temperatures are from six hours' tests at New York Navy Yard, made on Siemens dynamo built under Admiralty specifications.

	Heating of Shunt field.		Heating of Series field.	Heating of Armature.
	In 1 minute.	Max.		
200 amperes,	21°	40°	35°	46°
300 amperes,	16°	33°	38°	43°
400 amperes,	..	39°	39°	35°

The British specifications contain many minor provisions, but leave the design and construction of the dynamo almost entirely to the maker. The prevailing type has been for several years the bipolar vertical magnet.

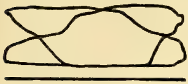
The engine specifications call for vertical, inverted, direct, double acting engines. These are open, the closed in types having been abandoned. The most important proviso is that the governor shall be so arranged as to allow the speed to be varied while in operation. This necessitates a throttle governor and causes an absolute sacrifice of what, in the estimation of the American elec-

trician, is the most important consideration, viz., close regulation. Another consequence is the advisability or even necessity of changing the setting of the valves if the working steam pressure is largely varied, or if the exhaust is changed from atmospheric to vacuum. The throttle governor, while able to reproduce a speed after a sudden change of load, can act only when a large momentary increase has taken place. This is, of course, attended with a corresponding rise in the voltage of the dynamo, injuring any incandescent lamps left in circuit. The Admiralty specifications allow a temporary increase of speed or "jump" of 25 per cent.

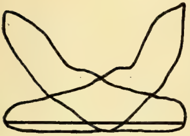
As this system is almost universal in Europe, it may be of advantage to contrast it with that used in the United States Navy. Our specifications allow of a variation of speed of only five per cent. when the whole load is thrown off the dynamo, and although this strictly applies to the difference between the steady speeds of the engine loaded and light, it is seldom exceeded even in the "jump." The latter is directly controlled by another proviso that the dynamo voltage as indicated on a dead-beat voltmeter shall not show a variation of more than ten volts when full load is thrown on or off. This closeness of regulation is obtained by the use of what is commonly known as the "automatic governor," acting directly on the eccentric and changing the throw of the valves, altering the point of cut off, and also adjusting the compression to suit the change of load. No commercial electric light engine with a governor operating on any other principle could be sold in the United States, while only two naval dynamo engines were seen by the writer in Europe in 1891 that used it. The indicator cards shown in Figure 12 illustrate the capacity of this variety of governor to adjust the working of the engine to variations of steam pressure and exhaust. The reason for the retention of the throttle governor is found in the fact that European dynamos are self-contained, the field circuits being entirely on the frames. As the dynamo heats the voltage can be adjusted only by an increase of speed. American dynamos, on the contrary, always have an adjustable exterior resistance in the shunt field circuit, by varying which the voltage may be changed as desired. With a dynamo of this type constant speed is desirable, and automatic engines are therefore invariably used. It is difficult for an electrician accustomed to the facility of adjustment thus obtainable, to conceive of any compensating

24 K. W. SET, No. 3.

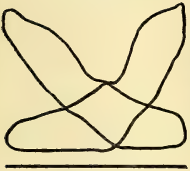
Diameter of Cylinder	10¾	inches.
Diameter of Rod	1⅝	"
Stroke	6	"



Spring	50
Steam	40
Vacuum	..
Revolutions	393
Volts	80
Amperes	300



Spring	50
Steam	60
Vacuum	27
Revolutions	395
Volts	80
Amperes	300



Spring	50
Steam	80
Vacuum	..
Revolutions	399
Volts	80
Amperes	300

FIG. 12.

advantages which justify the abolition of the adjustable rheostat. To him nothing is cruder and practically more inconvenient than the method of adjusting the voltage of the machine by setting up with a monkey-wrench on a nut regulating the tension of the governor spring of the engine. Messrs. G. E. Belliss & Co., the principal contractors for Admiralty dynamo engines, have recently constructed automatic engines for commercial marine use, but so far as is known they are not yet used by the Admiralty.

The following table illustrates the difference in regulations between the two types :

	Alexandra.*	Crescent.*	Colossus.*	Miantonomoh.	New York.	Puritan.
Revolutions full load,	312	324	333	397	382	393
Revolutions on throwing off load........	395	390	378	411	391	398
Per cent. increase....	26.9	20.3	13.5	3.5	2.25	1.25
Revolutions, no load,	315	327	338	402	389	394
Per cent. of change of steady speed......	.9	.9	1.5	1.25	1.75	.25

*The data for the English ships are taken from Marine Electric Lighting, by H. Cuthbert Hall.

Returning to the Admiralty specifications, another most important proviso is one promoting economy. This is based on water consumption. The contractor, in tendering a bid, guarantees a certain water consumption per hour per electrical horse power, under penalty for each pound of water in excess. The consumption is generally determined by measuring the feedwater. This method is apparently superior to the one called for in our specifications of determining efficiency from indicator cards, as it is simple, practical and not liable to great error. The measurement of feedwater checks up any condensation in pipes or cylinders against the engine, and the consumption is therefore sometimes found by a surface condenser, this process, of course, favoring the engine.

The French Navy seem to have no standard specifications, the requirements varying for different vessels. The heating proviso, which dominates the whole dynamo design in our own specifications as well as in the Admiralty, is very elastic, the only demand being that it shall be "tres faible." This is said to be construed as 35° C. above the air in a six hours' run, a much greater limit than our own. The controlling feature in the French specifications is that of economy. As in England, this is determined by water consumption per electrical horse power at terminals. The specifications fix consumption which must be obtained under penalty for every decilitre in excess, a limit being also named, the exceeding of which justifies total rejection. A variation of two per cent. is generally allowed in the steady speed of the engine between light and full load. The governor must be adjustable while in operation, and this proviso calls for the throttle governor, with regulation of speed by adjustment of the governor. As a result of

the above requirements we find the French dynamo to be small and compact and generally operated by compound engines. Many multipolar dynamos are in use, but in recent installation it is understood that bipolar are preferred.

The tests for acceptance are of two kinds. One is made before the installation of the dynamos on shipboard, generally including two six hour tests at full load, one on atmospheric exhaust and the other on vacuum, each with specified steam pressures. In each case a certain economy must be attained, penalties being exacted for any excess as above stated. It is understood that the tests of the sets for the Marceau gave an economy of 12.2 kilos of water per electrical horse power at terminals, while those of the Neptune gave a consumption as low as 11.7 kilos. At these tests all measurements of insulation and copper resistance are made. If the first tests are successful, the sets are installed on shipboard, and when in place are subjected to another continuous test of twenty-four hours at full load.

Although the French dynamos are not made large by the imposition of a low heating limit, it is noticeable that, in spite of their apparent compactness, they occupy nearly as much floor space as the later American types and are but little, if any, lighter. They are invariably of a high degree of mechanical excellence.

The dynamo apparatus of the German Navy is made either by Siemens Halske of Berlin, Schuckert of Nuremberg, or Kummer of Dresden. Each manufacturer has his own type, most of the recent apparatus having been made by Kummer. One of his types is somewhat like that in use in our service aboard the Philadelphia and Baltimore, but a later type is a ring frame having six interior poles. Incandescent lighting is subordinated, in the German Navy, to the search-light. As the Schuckert projectors in use each take 150 amperes, the practice is to install a 180-ampere dynamo for each projector, leaving but a small margin for simultaneous operation of incandescent lights. The dynamos are never coupled in parallel, and the incandescent lighting is, therefore, comparatively ineffective. Although the general type of apparatus is much like the French, Kummer has made dynamos having adjustable rheostats in the shunt fields and driven by automatic engines.

The foregoing is merely an outline of the prevailing character-

istics of the dynamo machinery in the principal foreign navies. The one point which remains for us to notice is that of economy. More stress is laid on this abroad than in our own service, although our specifications call for a percentage of efficiency taken as the ratio of indicated horse power to electrical horse power at the terminals. It is certainly most desirable to have economical dynamo apparatus, but the question of economy presupposes certain working conditions which have to be met. No engine or dynamo is economical when operating at a fraction of its normal output, or with one-half its normal steam pressure, and yet these are exactly the conditions under which our naval dynamos operate two-thirds of the time. Moreover, economy of working depends mainly on the boiler, and as long as the main boilers are used for generation of steam, the consumption of coal must be excessive for the amount of work done. While these considerations will not justify an uneconomical engine or inefficient dynamo, they indicate that economy of actual working depends on many circumstances, and that it may be better practice to design our machinery with special reference to durability and good working under the conditions holding on shipboard. This is the policy that has been followed, and although our dynamo engines are probably not as economical as others, they have a margin of power which, in connection with their automatic governing, makes them largely independent of all variations of steam pressure, enabling them to carry their load on half pressure, and, so far as is possible with a high speed engine, to work with wet steam. Compound engines have been but little used in our navy although not forbidden by specifications, the increased complexity and the ordinary low working steam pressure rendering them of practically no advantage.

American specifications call for the operation of dynamos in multiple, while in other services it is unknown. The advantage of parallel working is in the fact that it minimizes the effect of injury to any one dynamo. In a ship supplied with gun motors and search-lights, the demands made for electrical energy in time of action would vary suddenly and largely, so that it would be impossible to distribute the load on separate dynamos without having great excess of power. In such a system, each dynamo must have a reserve power sufficient to cover all demands made

upon it, although nine-tenths of the time it may be working light. This would hold of each dynamo of the plant. By yoking all together, however, we can take advantage of the fact that it is improbable that all motors will simultaneously be working at their maximum, and if not, there is a safe margin of power. The dynamo plant should, however, have an output equal to all demands made simultaneously, and the system of parallel connection would then prevent a total break-down of any motor mechanism from the fact that one or more dynamos may be injured. The advantage of the system is so evident as hardly to admit of question, and the fact that parallel working of dynamos is hardly thought of in any other service than our own must be explained by the difficulty of carrying it out without the automatic engine and the rheostat in the shunt field of the dynamo. Its practicability is abundantly proved by the habitual operation of compound dynamos in parallel in almost every power station in the United States; its military advantages have already been set forth, and justify the use of the method on shipboard.

CARE OF PLANT.

The conditions existing aboard men-of-war are specially trying to dynamo apparatus, and even with the best of care deterioration is more rapid than is usual ashore. The continuous operation of the dynamos, the high temperature of the dynamo-rooms, the presence of salt water and salt air, and the inevitable wear and tear attendant upon the crowded condition of the ships, are all difficulties to be encountered, but intelligent care will materially assist in overcoming them and in minimizing deteriorations.

A great part of the trouble experienced on shipboard arises from the engine. A high speed engine, especially if working with a small clearance, as in the Armington & Sims type, is specially sensitive to water in the cylinders, and but very little is required to cause a break-down. This danger can be much reduced by careful arrangement of steam and drain pipes. The dynamos are now supplied by independent steam pipes, and these are as straight as possible, and without any drop bends in which water may accumulate. Separators are generally placed in the dynamo-room, but cannot be relied upon to prevent all access of water. The

engine drains are found to work well on a vacuum if piped directly into the exhaust, but when operating on the atmosphere, must be led into traps, special attention being paid to avoiding back pressure. The engine cylinders are fitted with automatic relief valves, but a valve is frequently put in the drain pipes back of these, and if shut, prevents their action. The dynamo attendants must thoroughly understand the drain piping, and see that the drains are always clear. Care must be taken on starting the engine to drain the pipes and work all the water through at low speed, and as this precaution is obvious, accidents do not often occur then, most of the damage by water being done while the plant is in full operation, and is due to foaming or priming in the boilers, causing a sudden lifting of masses of water into the pipes. Shifting from one boiler to another sometimes causes trouble from water having accumulated in the pipes. Implicit reliance cannot be placed in such cases on either automatic drains or separators, and safety requires the slowing of the engines if the noise of water in the cylinders is serious. The Armington & Sims' engines in service seem to break the crossheads from the effects of water oftener than any other part. The only accident of this kind, within the knowledge of the writer, happening to one of the new engines, resulted in breaking the piston.

Heating of crank pins and bearings may, of course, be due to the shaft being out of line, or to bad fit of the brasses. The latter is easily remedied; the former is not liable to occur, as every engine is subjected to a run of at least two days before being put in place. If heating occurs in engines which have previously given satisfaction, it is probably due to dirt and grit in the oil cups, or to the brasses being set up too tight. One cause of injury to the plant is frequently found in the lack of mechanical skill of the force. Dynamo engines have been found cut and scarred by the marks of cold chisel and hammer used to start nuts or back out pins, while many parts are upset by hammering. No criticism of such treatment is needed.

The dynamo also requires reasonable care and intelligent treatment. The field coils are liable to have their cotton insulation rotted by moisture, or charred by overheating. The former would probably occur only when the dynamos are laid up for a long time. The overheating is, however, an effect of use. One of the most

common causes of overheating the field coils is operating at too low a speed, with the mistaken idea of saving wear and tear on the engine. If the latter is properly designed it will be as durable when worked at its normal speed as at any lower. If the dynamo is below speed a stronger current is necessary in the shunt field coils, in order to maintain normal voltage, and as the heating varies as the square of the current, the variation of temperature is much greater than that of speed. If the field coils be found to overheat, the defect may be diminished by increasing the speed and lowering the voltage if necessary.

Armature bearings give little or no trouble, as there is ample surface and no side thrust on the shaft. The armature itself requires no special attention beyond mechanical protection. This should not be such as to prevent good ventilation of the coils.

The point of most rapid deterioration of the dynamo is the commutator, and nowhere is care more required. Damage to the extent of hundreds of dollars may be done in a short time by allowing the brushes to spark heavily. The commutator segments are now made of hard copper or bronze, and are one and a half inches deep. No material can be used, however, which will stand heavy sparking. The ordinary injuries to the commutator are of two kinds, due to scoring and sparking. If a hard copper brush is used and the springs are set up with considerable tension, the commutator segments are scored and cut by the friction, and everything in the vicinity becomes covered with fine copper dust. The tension should always be as light as possible and regulated after the brushes have been placed at the neutral points. Sparking may be due to a great many causes; in fact, almost any defect in construction or design of the dynamo manifests itself in this way. As all dynamos are tested, however, before being placed on shipboard, and excessive sparking is sufficient reason for rejection in these tests, anything of the kind noted after installation is probably due to some defect which has been developed and necessitates careful inspection to determine the cause. It will, in general, be found to arise from defective insulation on the armature causing either a heavy ground or a cross. If the defect is on the outside, it may be repaired by covering it with shellacked tape, but if on an inner turn, the coil must be rewound. The Gramme armature, almost exclusively used in the Navy, has the great advantages of

not being liable to short-circuits, and of being easy to rewind if they do occur. In naval practice, armatures have burned out only from actual mechanical injury ruining the wire, or from general deterioration of insulation due to continuous overheating. The first can be guarded against by careful handling and treatment, the latter by avoiding excessive overheating.

There is a great difference in dynamos as to sparking, depending mainly on the strength of the field and on the distribution of the lines of force. Every coil is short-circuited as it passes under the brush, and if it is at that moment generating electromotive force, there will be heavy sparking. It is possible to so arrange the field of the dynamo as to have an electromotive force generated in the coil opposing that due to the short-circuiting, and in this case, the short-circuited coil will be practically dead and no spark occurs. In any dynamo in operation, the standard rule is to set the brushes at the position of minimum sparking. If it occurs on one set of brushes and not on the other, it shows that they are not at the right distance apart, and one set must be moved to bring both at the neutral points. Sometimes the brushes may be too narrow, and it will be found advantageous to spread those on the brush holder, so as to cause them to make good contact on two commutator segments.

Gauze brushes have recently been tried and are found very satisfactory, as, while admitting of sufficient tension for good contact, they do not score the commutator. Carbon brushes are largely used in shore practice in cases where large and sudden variations of load take place. They do not obviate the sparking, but render it less injurious, the brush wearing away instead of the copper of the commutator. They should have a cross section of at least one square inch for every fifty amperes to avoid heating.

Once in place, the fixed wiring of the ship should cause but little trouble. The insulation on the wire in the fire-room is apt to deteriorate from heat, becoming harder and more brittle, and therefore more liable to injury. Most of the deterioration in the fixed wiring occurs, however, in the receptacles, switches and junction boxes. Unless care is taken to always have these screwed up tight, moisture or water is liable to find its way inside, where it is held and slowly corrodes the copper of the conductors. Steam-tight globes also are frequently not set up firmly on their

rubber gaskets. The standard fittings are water-tight only when care is taken to keep them so; if neglected, water will work in and remain. Portable double conductor wire is sometimes treated by the crew with about the same consideration that they give a hawser and is, of course, rapidly worn out. The latest type is stronger and more durable than that formerly issued, but should have intelligent handling.

Rubber covered wire should not be painted. Many pieces have been taken out of ships in which the rubber had been rotted by the oil of the paint. If different colors are desired, they should be made with colored braid.

The automatic search-light lamps should be occasionally overhauled, a little jeweler's oil on pivots materially assisting their working. The tension of the springs should be occasionally looked to, that the lamps may feed at the proper potential, which varies from 45 volts when using 50 amperes to 52 with 100 amperes. The lamp should always be left with a good crater and with the carbons properly placed. Sufficient experience has not yet been gained with the electrical control apparatus to predict its special weakness in service, although it is safe to say that its complexity is such that reliability can be obtained only by constant care. The search-light mirrors should be kept clean, and when working with heavy currents in very cold weather it is probably advisable to keep them protected from sudden changes of temperature. The mirrors are sometimes broken by the blast of the guns, but this will seldom occur if the projectors are placed at a proper distance from the latter. The plane glass doors are more liable to injury and are made in standard strips, any one or more of which can be replaced at little expense.

The indicating electrical apparatus thus far installed in our navy has not given satisfaction in service, although working well enough in tests ashore. Other systems will be installed for trial, and with care it is hoped will give good results.

The present type of fixtures and many of the fittings are finished in dark bronze. The durability of this finish is doubtful. As it is lacquered it requires no cleaning except an occasional wiping off with an oily rag. Any scrubbing or polishing is liable to rub off the film, exposing the metal underneath.

The care necessary for the proper preservation of a complex electrical plant can be given only by thoroughly trained men. Whatever electricity may do in the future, it will always depend on human intelligence for the full development of its power, and all complex electrical apparatus requires attention to keep it in working order, as well as technical skill for its operation.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

ARMING OF THE BRAZILIAN CRUISERS NICTHEROY AND AMERICA.

By Howard P. Elwell, Associate Member of U. S. Naval Institute.

It is well known that the Bureau of Naval Intelligence at Washington has in its possession plans of all the merchant vessels sailing under the U. S. flag which could be converted into armed auxiliary cruisers. It is understood that designs for arming these vessels have been prepared. Certainly such information and data should prove of inestimable value in case of sudden emergency, but as yet no opportunity has arisen to call for the practical execution of such plans.

It will be readily granted that the simple execution of well prepared plans would be quite a different matter from arming a vessel complete without the least previous knowledge of her construction, when the time limit was extremely short, and the material scattered not only over this country, but beyond the Atlantic as well.

The recent conversion of the merchant vessels El Cid and Britannia into the armed cruisers Nictheroy and America for the Brazilian government presents an object-lesson, the value of which can scarcely be overestimated. These two ships, together with the pleasure yachts Feiseen and Javelin, were so quickly transformed from their peaceful condition into efficient fighting vessels and torpedo-boats, as to astonish naval officers and others having knowledge of the circumstances.

It is thought by the writer, who took an intimate part in the practical work of installing the battery, that a résumé of the work would prove of interest, possibly of value.

NICTHEROY.

The El Cid, now Nictheroy, is a steel vessel of 2,908 net tonnage; 407 ft. long and 44 ft. wide, built in 1893 for the Morgan line by the Newport News Ship Building Co. She was built strictly for freight, the construction being first-class in every particular. The vessel has spar, main (converted to a gun-deck), a lower deck running the whole length of the ship, and a short deck still lower, both forward and aft. There are three deck-houses, one forward, connected to the pilot-house, one long house amidships, and one short house aft. These were left, but the wheel-house aft was removed to permit complete train of after gun. She is provided with triple-expansion engines capable of driving the vessel at a speed of 17 knots. Extra coal bunkers were so arranged as to protect, as far as possible, the engines and boilers.

The battery decided upon depended (as would be the case in any emergency) on the material available. It was as follows:

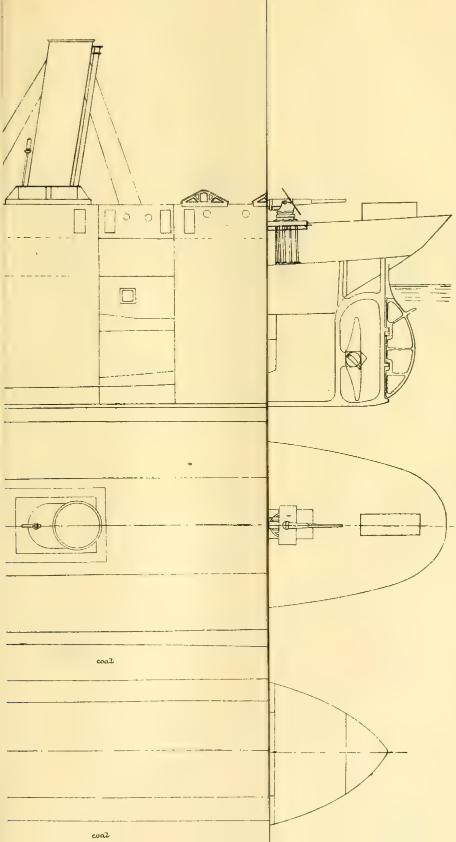
One pneumatic gun, 15-in. calibre.
One Hotchkiss rapid-fire, 12-cm.
Two Hotchkiss rapid-fire, 10-cm.
Eight Hotchkiss rapid-fire, 6-pdrs.
Nine Hotchkiss rapid-fire, 1-pdrs., 7 heavy, 2 light.
Two Hotchkiss revolving cannon, 37-mm.
Four Hotchkiss torpedo launching tubes for Howell torpedoes.

The ammunition supplied was as follows:

50 rounds, fixed, for 12-cm. gun.
200 rounds, fixed, for 10-cm. gun.
1419 rounds, fixed, for 6-pdr.
200 rounds, saluting, fixed, for 6-pdr.
540 rounds, fixed, for 1-pdr., heavy.
600 rounds, fixed, for 1-pdr., light.
10 Howell automobile torpedoes, complete, with war-heads.
1 full calibre projectile, loaded, for 15-in. pneumatic gun.
7 10-in. sub-calibre projectiles, loaded, for 15-in. pneumatic gun.
3 10-in. sub-calibre projectiles, to be loaded on board.

Not a very heavy battery, it is true, but one requiring a vast deal of work when it is considered that not even a preliminary plan was at hand, while the ship had to be prepared, the material ordered and shipped from various sources, received and placed on

ROY.



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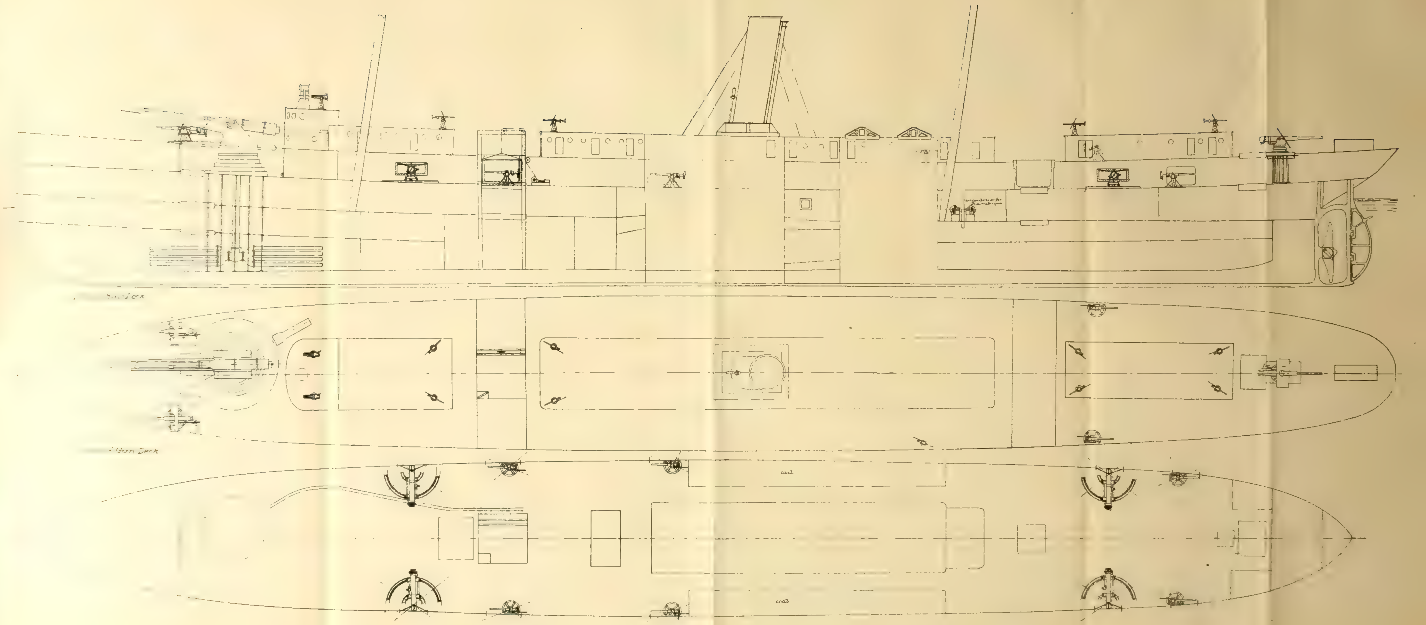


board in service condition; gun mounts located and bolted down, carriages assembled, guns mounted, torpedo tubes placed and connected to steam and exhaust pipes, magazines located, designed and fitted, ammunition, gun-cotton and other explosives received and stored, etc., and all this in twenty days. Material was received from Paris, Chicago, Providence, New Haven, Hartford, Cold Spring, Wilmington and Springfield, and, so far as known, not a package was lost or misplaced.

The armament being decided upon, the first thing to be done was to decide upon the exact location of the several guns, tubes, etc., locate and design the magazines, all the while considering methods of strengthening and means of transporting ammunition.

THE PNEUMATIC GUN.

The pneumatic gun, with all its accessories, was unquestionably the most complicated and awkward piece of mechanism ever installed on a floating vessel, and required a vast deal of preliminary work for its reception.

An opening, circular in shape, 26 ft. in diameter, but flattened forward, was cut clear through the spar-deck, beams and all, the centre being 3 ft. to starboard of the midship line. Coamings about 14 in. high, of ½-in. plate iron, were fitted around this opening through which the gun and its carriage were to project. The gun was thus placed off the amidship line simply to permit direct ahead fire and not interfere with forestays and other necessary obstructions in the eyes of the ship.

Directly under this opening, on the main deck, a huge circular pile of timber, 18 ft. in diameter at the bottom, was built of 12 in. x 12 in. yellow pine, five courses high, each course tapering in steps toward the top. This is the foundation on which rested the carriage for the pneumatic gun. Under the main deck and between successive decks, 4-in. stanchions were fitted, extending down to the bottom of the ship to support the immense weight of carriage and gun. A circular opening was formed in the centre of the wooden pile to receive the air-pipe from accumulators below to the gun, also for such wires, etc., as were required for the electric motors working the carriage. The wooden foundation was very securely bolted through and through and down to the deck. A

heavy cast iron base ring resting on top was bolted down through to the lower deck.

When mounted, the carriage and gun projected through the opening in the spar-deck, giving the gun a clear range forward and permitting training on both bows. In this respect the installation of the gun is entirely different from those on the Vesuvius; the carriage, which was built for land service, as mounted permits not only training but also elevation of the gun.

The accumulators were fixed in the lower hold on the starboard side directly under the gun, a central air-pipe leading up through the foundation as described.

The air-compresser of the Rand horizontal double-direct acting type was installed on the between deck just aft of the engine-room bulkhead; steam-pipes from the boilers and air-pipes to the accumulators forward were led through the various bulkheads to their respective positions.

The projectiles were stored in the lower hold on the starboard side, the means provided for their transportation to the gun being quite elaborate. An elevator of the ordinary freight pattern, worked by a hoisting engine installed on the main deck, was fitted to run up through the main cargo hatches forward from the lower hold to the main deck. The projectiles are first loaded on the elevator in the hold, raised to the main deck and rolled into a loading trough (as it may be termed) resting on four trucks. The loading position of the gun is in a horizontal plane trained over the port bow. The trough with the projectile is run forward over a light guide-rail along the main deck to another elevator, which conveys it up through the spar-deck, and from this the projectile is loaded into the gun.

The gun and carriage are manipulated from the spar-deck, light shields being provided to protect the gunners and the air-valves, levers, etc., which otherwise would be entirely exposed.

TORPEDO TUBES.

The torpedo launching tubes were of the broadside type and were located on the main deck, ports being cut through the side of the ship eight feet long and two feet wide. Port shutters in two sections which could be opened independently were fitted with hinges on the bottom, so that the torpedo would be protected from

light fire until the last moment, when it would only be necessary to slacken one bolt and push the shutter open, its weight insuring its dropping and keeping out of the way.

The launching tubes requiring steam for use by the motor in spinning up the fly wheel of the torpedo, connection with steam pipes from the boiler was necessitated. In order to permit training of launching tubes, a special arrangement of the steam and exhaust pipes is required. Where these are to pass through a deck the steam pipe passes inside through the exhaust pipe, one end of each being screwed into a special cast elbow provided with passages and openings for both the steam and exhaust pipes. The other end of these pipes is fitted to a similar elbow, but in place of being screwed in is arranged to swivel through a stuffing box formed in the end of the elbow. This arrangement requires but one hole through the deck at the centre on which the tubes are to train, the exhaust pipe forming the point for the tube.

Steam and exhaust pipes were found on the ship in the channels where they were originally placed for leading steam to winches and capstans. These pipes were cut wherever a tube was located, turned back against the side of the ship and tapped for connection with the steam motor on the tube. These connecting pipes were carried down through the deck and made into the double elbow described above.

Wooden deck circles were fitted to the sheer and crown of the deck and leveled on top to receive the metal deck circles of the tube, and a wooden block was bolted to the channel-plate to receive the steam pipe pivot. Care was exercised in making up the connections to insure against danger from expansion of the long pipes in the channel, loops being formed in the copper pipe used for the purpose. A steam and exhaust valve was provided for the two tubes forward and the two aft respectively.

Near the outer end of the tube and around it was a light band, on top of which a pintle was formed. This pintle was so adjusted as to be directly over the centre of the steam pipe pivot below, and turned in a socket which was bolted to the frame-work of the port by flat-iron braces. The lower carriage supporting the tube is also braced from the steam pipe pivot.

The tubes were located directly athwartships from each other, two forward and two aft. The torpedoes with practice heads com-

plete were stowed in boxes amidships between the tubes. These boxes were a sort of combination loading-trough and stowaway box, the bottom forming a loading trough when the cover was removed, in which the torpedo rested and from which it could be pushed forward into the tube. A rope bale was provided so that the trough could be suspended, and the torpedo pushed out through it. A light overhead rail of 3 x ½-in. flat iron was suspended from the deck above and ran across from tube to tube. A light trolley with chain falls of the ordinary commercial pattern was provided for handling the torpedoes.

No strengthening of the ship was required for the torpedo installation beyond a heavy iron frame of 6 x 1½-in. iron at the ports. This was simply to supply strength lost by cutting through the two frames of the ship, in forming the long ports.

THE 12-CM. GUN.

The 12-cm. gun was located aft of the after-deck house. The wheel-house having been removed and the steering gear protected by a 2-in. steel armor plating, the gun had a clear stern fire and could be trained on either side to about 30° forward of the beam.

The spar-deck being entirely too light to resist the shock of so heavy a gun, a plan of strengthening was adopted, which it is believed could be employed to advantage in many cases, so distributing the strains that a gun of considerable weight could be safely mounted on a vessel of very light construction. The position most desirable for the gun, while requiring the removal of a steam capstan, utilized the strengthening originally designed for that purpose. The wooden deck was cut away for a space 6 ft. wide by 8 ft. long. An iron plate ⅜ in. thick was found on top of the beams and another 1 in. thick, to which the capstan engine had been bolted, under the beams. A wooden platform of yellow pine timbers, 12 x 12-in., was bolted down in the space cut out of the deck and leveled off on top about 8 in. above the line of the deck. The base ring for the mount was bolted down through this platform and the iron plates, the bolts extending down through the main deck below. Each bolt passed through a 4-in. double extra thick pipe which fitted closely between the iron plate under the spar-deck beams and the main deck below, resting on

heavy cast-iron steps made for the purpose. When the bolts were set up, it will be seen that a very strong, rigid structure was formed, capable of resisting heavy shocks.

THE 10-CM. GUNS.

The 10-cm. guns were mounted forward on the bluff of the bow one on each side. They could be trained directly ahead, on broadside and nearly astern, being limited in this direction only by the deck-house. With the pneumatic gun elevated slightly, either gun could be fired across bows nearly abeam. Platforms of 12 x 12-in. yellow pine timber 6 ft. square were fitted to the sheer and crown of deck and leveled on top. Two heavy iron clip stanchions were fitted from the deck beams under the platforms to the main deck below. The bolts passed through the base ring down through the platform and deck, setting up on a 1-in. plate placed under the beams. A bulkhead, just forward of the mount, added materially to its support.

THE 6-PDRS.

The eight 6-pdr. guns were distributed equally on each broadside, six on the gun-deck at original freight ports and two on the spar-deck at the forward end of the after-deck house. The shape of the base of the mounts and size of the ports on the gun-deck permitted a total train of about 100°. The two guns on this deck aft were so located that a train aft of the beam of about 70° was possible. The four guns at the midship and forward ports were located so as to give about 70° forward train. The two on the spar-deck had almost a clear fore and aft fire, being limited only by the rigging and danger of firing close to the deck-houses.

The mounts on the spar-deck rested on and were bolted through platforms of 8-in. yellow pine timber in addition to the deck. The mounts on the gun-deck rested directly on the deck itself. The ship was constructed with a heavy steel plate over the main deck beams at the side, running fore and aft, so that the outer bolts of the mounts passed through it, the inner bolts passing through the 4½-in. deck only.

1-PDRS.

The nine 1-pdr. guns were distributed on each side, 2 on the after corners of the forward deck-house, 2 on the forward corners

of the deck-house amidships, 1 on the port side of the spar-deck near the after end of deck-house amidships (a circle was placed on the opposite side, but there was no gun for it), 2 on the forward corners of the after deck-house, 2 on the after corners of the after deck-house. These guns, with the exception of two, were all of the heavy pattern, on recoil mounts and shifting stands.

Extra deck circles, to the number of nine, were provided so that the guns could be remounted in any position found desirable at any time. Six of these were not bolted down, owing to lack of time. No special features occurred in mounting these guns. Through bolts were used on the deck-houses to bolt down the deck circles, lay bolts where deck circles were bolted to deck.

37-MM. REVOLVING CANNON.

The two 37-mm. revolving cannon were located on the pilot-house, one on each side. They were mounted on the standard 1-pdr. cage-stand, and each had direct ahead, clear broadside and nearly astern fire. The stands rested on wooden platforms of 3-in. yellow pine and were bolted through the top of the pilot-house.

MAGAZINES.

Two magazines were provided, one on the port side in the lower hold just forward of the fore-cargo hatch. They were built of 3 x 4-in. scantling and matched boards and lined with zinc. They were divided into several compartments for the various sizes of ammunition and explosives, all opening from one ample passage way. They were well lighted from the outside by electric lights. Arrangements were provided for flooding.

A light elevator, worked by hand, floor 2 x 3 ft., was provided at each magazine, running straight up through the hatches. A number of light trucks were also provided for distributing the ammunition from the elevator to the several guns.

Five of the Howell torpedoes being stowed between the forward launching tubes and five aft, the corresponding war heads were stowed in the magazines below. These heads were the actual heads of the torpedo, of brass, and contained each about 92 lbs. of wet gun-cotton in discs fitted directly to the inside of the heads, which are provided with water-tight bulkheads. The loaded head

is stored in a wooden box 34 in. long, 16½ in. wide and deep, and handled in this way until removed on deck to be connected to the torpedo for use.

The dry gun-cotton primers for the torpedoes, containing each 2 lbs. dry gun cotton, are brass tubes with wooden caps fitted with cork bottoms. Five of these primers, separated by blocks, are stored together in a wooden box and kept in a closet in the captain's room.

The detonators, containing each 30 grains of fulminate, are stored in small pine boxes, in which holes are bored to receive them. The holes and cover are lined with velvet. The boxes are kept in a safe place in the captain's room.

AMERICA.

The Britannia, now America, an iron ship of 672 net tons, displacement 2600 tons, 260 ft. long, 34 ft. wide, loaded draught forward 17 ft., aft 19 ft., was built in Bergen, Norway, expressly for tourists' excursions. The vessel has triple-expansion engines, originally capable of driving the ship at 16 knots, but the introduction of a steam fan for forced draught is expected to increase her speed at least 1 knot.

The vessel has but one main deck available for mounting guns. A short deck-house forward and one aft were entirely removed, leaving a clear space forward and aft of the main deck-house for gun platforms; the top of the deck-house is widened out over the passage way between the deck-house and the rail, forming a promenade deck, the outer edge being supported by stanchions from the main deck below.

Locations for several small pieces were found on this deck.

The steering gear and engines which were entirely exposed aft on the main deck were covered and protected by a 2-in. armor plating. The ship was constructed with a ¾-in. iron tie plate 4 ft. wide, running clear forward and aft along each side over the main deck beams. This plate furnished a very strong support for guns mounted on the broadside.

The battery installed was as follows:

Two Armstrong 4.72-inch quick-firing guns.

Two Hotchkiss 14-pounders.

Six Hotchkiss 6-pounders.

Six Hotchkiss 1-pounders, light.

Four Hotchkiss torpedo launching tubes, for Howell torpedoes.

The ammunition furnished was as follows:

200 rounds for 4.7-inch guns.
250 rounds, fixed, for 14-pounders.
1332 rounds, fixed, for 6-pounders.
100 rounds saluting 6-pounders.
660 rounds, fixed, for 1-pounders, heavy (for the Nictheroy).
1400 rounds, fixed, for 1-pounders, light.

Eight Howell automobile torpedoes, complete with war-heads.

One Sims-Edison torpedo stowed on top of the hurricane deck abaft the foremast.

For the Nictheroy:

Two full calibre projectiles to be loaded on board.

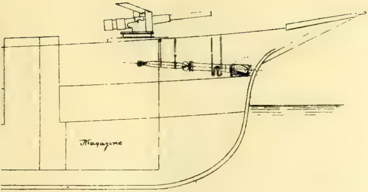
Sixteen 10-inch sub-calibre projectiles to be loaded on board.

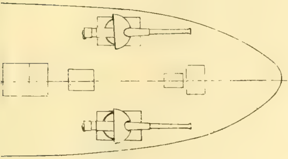
THE 4.7-INCH QUICK-FIRING GUNS.

The two 4.7-inch Q. F. guns and mounts were of the very latest Armstrong pattern, fitted with all the latest improvements. They were mounted forward, one on each side on the bluff of the bows. Platforms 10 ft. long by 6 ft. wide of 12 x 12-in. yellow pine timber were fitted to the sheer and crown of deck, and leveled on top. No other strengthening was supplied at these points, as the ship seemed to be so strongly constructed as to need none. The bolts passed down through the base ring of the mount, the platform and deck. The carriages were fitted with curved upright shields with slanting roofs. These guns, like the two after guns, were staggered; that is, by mounting the port gun abaft the starboard one, beam fire from both guns was possible on either side.

14-PDRS.

The two 14-pdrs. were located aft, one on each side, one ahead of the other, so that each gun had not only a complete aft train and about 60° forward of the beam, but both could also be trained on either broadside. These guns rested on wooden platforms 10 ft. long by. 6 ft wide of 12 x 12 in. yellow pine timber fitted to the deck and leveled on top. The platforms were built almost over the place left on the deck by the removal of the after deck-


Magazine



Six Hotchkiss 1-pounders, light.

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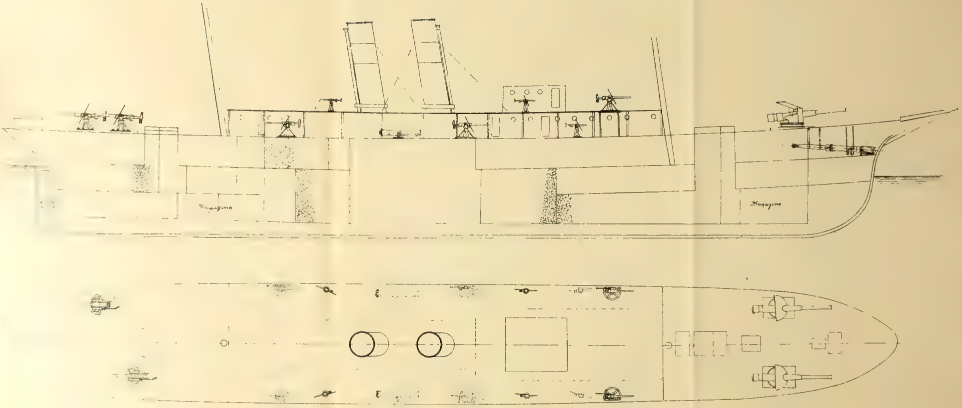


house. This place had been covered by ½-in. iron plating riveted to the deck beams and a 4-in. white pine deck flush with old deck. The bolts for the mounts extended through base ring, platform, and all but one or two through the ½-in. plating. It was intended that bolts should be passed through to heavy iron plates to be fitted under the deck-beams, but this was not done.

6-PDRS.

Four of the 6-pdrs. were located on the main deck in the passage way between the deck-house and the rail, two on each side, and rested on platforms of 3-in. yellow pine. Two others were located near the forward corners of the promenade-deck out over the passage way. 3-in. yellow pine plank was fitted under the projecting deck above for the mounts, and four 3-in. iron stanchions were tightly fitted between these planks and the main deck. Through bolts passed down through the base ring of the mount, the promenade-deck and the planks. All were provided with shields.

1-PDRS.

Two of the 1-pdrs. were located on the main deck, just forward of amidships. Four were located on the promenade-deck, two forward, and two aft. All were provided with shields.

TORPEDO LAUNCHING TUBES.

Two centre-pivot tubes were mounted as broadside tubes on the main deck amidships. Two were mounted as bow tubes on the deck beneath. The two centre-pivot tubes required very little preparation for their reception. A four-inch hole was bored through the deck, at the centre of which the tubes were to train. A complete deck circle of yellow pine, 5 ft. 2 in. in diameter, 3½ in. wide, and a circle 23 in. in diameter, both 1 in. thick, were fitted to the deck at the centre and leveled on top. The base ring of tube was lag-screwed to the 23-in. circle; the cone base of the launching tube fits down on the base ring and is held to it by a clip-ring which is fitted to act also as a clamp.

Small roller trucks on the tube rest on a ¼-in. iron circle screwed to the top of the deck circle, adjusted to carry the weight.

The same arrangement of steam and exhaust pipes as described

for the broadside tubes of the Nictheroy pass up through the 4-in. hole bored in the deck. Steam and exhaust pipes from the boiler lead into the double elbow below the deck. Valves were provided to be worked from the main deck near the tubes by wrenches through the deck plates.

The two tubes required considerable preliminary work. The forecastle in the eyes of the ship, under the main deck, was cleared out and converted into a torpedo-room, which ended aft in a heavy collision bulkhead. Holes were cut in the bow, one on each side, about 3 ft. below, and the same distance abaft the hawse pipes. Heavy castings, in the form of a tube, of an internal diameter somewhat larger than the launching tube, with flanges fitting the outside plating of the ship, were cast and bolted into place.

The front end of the castings were faced off, and the shutters grooved for a rubber packing ring.

The shutters were arranged to hinge to a lug formed on the casting so that they dropped down and outward, at an angle of about 45°. They were held in place against the rubber ring by a shaft forming the hinge bolt, to which they were keyed. This shaft extended through a stuffing box secured to the plating of the ship, and was provided on the inside with a long lever; the shutters could thus be opened or closed from the inside, a lashing at the end of the lever to a ring bolt in the deck securing the shutter in closed position.

The castings were so fitted that the centre lines of the tubes, while parallel to each other fore and aft, inclined downward ahead at an angle of about 4° with normal water-line. The launching tubes were entered into the ship through the openings cut in the bows before the castings were bolted into place. They were fitted into the castings, and made water-tight by two packing rings which fitted the tubes tightly, and were packed around the outside with oakum.

The after ends were supported by a light A-frame of 3-in. angle iron, bolted to the tube and to the deck. Steam and exhaust pipes direct to the motor were connected with steam and exhaust pipes passing through this same compartment for the windlass engines on the main deck above.

The distance between the rear of the tubes and the collision bulkhead being too short to permit loading of the torpedoes, cir-

cular openings 22 in. in diameter were cut through the bulkhead in line with the tubes. Water-tight doors were fitted over the holes to be removed only when loading a torpedo. Eye bolts in the deck above, in line with the tubes, were provided, one on each side, just to the rear of the tube, for a pair of chain falls, for handling the torpedo; the other farther aft, for supporting a ½-in. iron rod for supporting the end of the torpedo, and prevent its tipping when hoisted in position for loading, and while the primers and firing points are being adjusted before entering the torpedo into the tube.

On this ship it was thought best to economize space by loading a torpedo in each tube.

There being two torpedoes per tube the extra ones were stored in boxes, two in the forward torpedo-room against the collision bulkhead, and one on each side on the main deck just aft the centre-pivot tubes.

MAGAZINES.

There were two magazines, one forward and one aft. The forward magazine was located in the lower hold just forward of the fore hatch through which the ammunition was hoisted to the deck and distributed on trucks.

The after magazine was in the lower hold just forward of the after hatch through which the ammunition was hoisted.

The magazines were divided into compartments for the several kinds of ammunition, and were lighted by electric lamps.

Four war heads for the torpedoes were stored aft and four forward. They were in boxes as described for the Nictheroy. The dry gun-cotton primers and the detonators were stored in the captain's room.

TORPEDO-BOATS.

There were three torpedo-boats in the fleet. Two were converted from the yachts Javelin and Feiseen; the third being obtained complete, with the exceptton of launching tube, from the well-known English builders, Yarrow & Co.

The Javelin and Feiseen were stripped of their deck and pilot-houses and furnished with light steel conning-towers. The Feiseen had originally a long, low house over engines and boilers, extending aft over a cabin. This was all removed and a light steel deck

built over, crowned up in the centre to give head room in the engine and boiler-rooms. A blower for forced draught was added.

A centre-pivot launching tube was installed forward of the conning tower, the work necessary being precisely as described for the centre-pivot tubes on the America, with the exception of the connection of the steam and exhaust-pipes. These were made up in the usual way into the double elbow spoken of previously; but in the steam-pipe it was necessary to provide a reducing valve, as steam pressure in the boilers was in excess of the safety limit for the piping and steam motor on the tube.

The valve was set to furnish steam to the motor at 125 pounds pressure. The exhaust-pipe was so arranged that the exhaust could be delivered either into the condenser or outboard.

A low mount for a 1-pdr. R. F. gun was riveted to the top of the conning-tower, and a deck circle for a light steel cone mount bolted to the deck aft. One light 1-pdr., with the accessories and spare parts, was furnished to each boat. The pivot for the gun fitted both mounts and could be shifted to either position.

The work done on the Javelin was similar to that on the Feiseen, one centre-pivot launching tube and one 1-pdr. being fitted as on the other boat.

These two boats were hoisted and carried on the deck of the Nictheroy, one on each side amidships and secured in a cradle prepared for it.

The Yarrow boat was fitted with a bow launching tube. The stem and plating were cut through to receive the tube which was entered from the rear, the plating of the conning-tower being removed for that purpose; the tube passed through a hole in a bulkhead about 6 ft. abaft the stem.

The launching tube itself being too short for this boat, a short piece of tubing of wrought iron was rolled up, screwed and fitted to the end of the tube to extend it out through the stem. A plate of ¼-in. iron was shaped to the outside of the tube, flanged to the bow of the boat and riveted to it.

The inside extension piece being caulked to the outside plate and to the tube, itself, formed a perfectly water-tight joint; the inside end of the tube was supported by an A-frame, as in the bows of the America, and was also braced to the sides of the boat by light, flat iron.

The steam and exhaust-pipes were led directly through the boiler-room bulkhead and made up into the unions on the motor. A reducing-valve was fitted in the steam-pipe as on the other boats.

The torpedo for this boat must be loaded through the bow.

Mounts on the conning tower and aft were furnished, as on the Javelin and Feiseen; the gun, however, was a heavy 1-pounder.

The Destroyer, a craft well known as a vessel designed to carry a submarine gun, was also one of the fleet. In addition to her submarine gun a centre-pivot torpedo launching tube was installed on the deck forward. Two heavy 1-pounder R. F. guns, with 300 rounds ammunition, were added to her equipment. The gun-cotton for her projectiles and torpedoes was stored in the lower hold.

No alterations of any account were made in this craft beyond extra timber along her sides, wooden braces inside the light deck-house and a sea breaker forward, all to preserve her stability, and make her more seaworthy while on the voyage to Brazil.

A heavy steel wire hawser, secured by staples, was carried around the vessel and ended forward in a big thimble, to which was attached a ring and chain.

The Destroyer was taken in tow by the ocean towing tug Santuit, which also carried the Yarrow boat lashed on her deck forward.

The base ring of the launching tube was fitted to the deck of the Destroyer, but the tube itself, with the torpedoes, guns and other equipments were carried as cargo on the Santuit.

The El Cid arrived in port from commercial voyage Oct. 26. Cargo was taken out and the vessel put in dry dock.

On Nov. 18th, she dropped down the bay practically completed. The torpedo-boats were hoisted aboard the night of the 19th, and the vessel sailed on the morning of the 20th.

The Britannia arrived in port on Nov. 6th, went into dry dock, and dropped down the bay on the 24th. She sailed the next day, Nov. 25th.

One incident seems well to illustrate the expeditious manner in which all the work on both ships was performed. As stated above, the Britannia dropped down the bay on the 24th.

The two 4.7-in. quick-firing guns had not yet arrived, and only one carriage was at hand and in place. The guns and other carriage

were on the S. S. Germania, which arrived at the dock at four o'clock in the afternoon. It was found that the material required was at the very bottom of one of the freight-holds. Work was immediately begun on her cargo, and by midnight the material was on the wharf. The guns and carriage were hoisted on board a lighter in the morning, and one gun and carriage assembled; the lighter then started down the bay.

Meanwhile a tug had taken the base ring down to the Britannia, together with a gang of mechanics, so that by the time the lighter arrived with the carriage and gun, the base ring was bolted down in its place. The carriage and gun were hoisted on board, dropped into place and bolted to the base ring. The second gun was hoisted into place on its carriage, already in position. This work was fully accomplished, and the vessel started for sea by three o'clock in the afternoon of the same day.

This article has been confined strictly to a résumé of the armament of the fleet. The work performed in the other departments, the electrical work (both ships were completed, fitted with dynamos, two search-lights each, and lights in every part of the ship), the engineers' department, the stewards' division, and all were carried along at the same high pressure.

No better illustration could be had of what can be done in case of an emergency.

It must be borne in mind, however, that there were no hitches, that every one worked as for a common interest, and that no time was lost. When anything was found to be needed it was obtained without delay.

Note.—The accompanying plates are not intended to be accurate drawings of the ships. They are sketches to scale, and will serve to illustrate the relative positions of the various guns. The port forecastle gun of the America should be represented abaft the starboard one, as is shown in the case of the after guns.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

NOTES UPON THE NECESSITY AND UTILITY OF THE NAVAL WAR COLLEGE IN CONNECTION WITH PREPARATION FOR DEFENSE AND WAR.

By Comdr. C. H. Stockton,* U. S. Navy.

The events which precede and follow the outbreak of war progress too quickly to allow time for general or special reconnaissance of the theatre of operations, either at home or abroad. Hence this work which took place formerly in time of war should be made *now,* in time of peace.

This is particularly the case with naval warfare, for to the existence of men and vessels in reserve, and the powers of rapid assemblage, are added enhanced qualities of speed and sea endurance. These qualities give to naval operations such possibility of quickness and vigor in execution and increased length of reach, that the time permitted for preparation for defense is correspondingly shortened. Besides, measures taken upon the eve of war—a time of emergency and excitement—will naturally be imperfect, ill-digested and extravagant.

The sudden nature of war is historical. During a period of one hundred and seventy-one years, from 1700 to 1870, one hundred and seventeen cases of hostilities have occurred in the civilized world; one hundred and seven of which have been commenced by European subjects, or citizens of the United States, without due declaration of war.

With preparation for war and defense properly made, among other things by the study of past naval campaigns, of tactical

* Of the U. S. Naval War College.

evolutions in our own and neighboring coasts and waters, we then are in position to put into operation all the forces at our disposal at the outbreak of war; for in regard to this promptness of initiative, it is well said that "*Rapidity of movement kills in the germs a crowd of measures which the enemy would have taken.*"

Though a proper decision is also a matter of character, Col. Maurice, R. A., wisely remarks: "That a commander is much more likely to decide aright if he has in mind some large knowledge of the accumulated experience of the past, than if without anything to guide him he judges by a so-called common sense which has already led him to ignore the earnest advice of those who have been themselves most successful in war."

The questions discussed, and worked out at the Naval War College, relate to strategy, naval history, naval tactics, coast defense, torpedo warfare and international law.

These subjects are not fully studied elsewhere, and but one or two even touched upon at the Naval Academy, whose course is already crowded, and an extension of which would lead to a postponement of graduation, at an age too advanced for sea habits, and for the acquisition of that sea instinct and faculty so necessary for naval officers.

In addition, the study and acquisition of the matters dealt with at the War College require that officers should have considerable previous experience afloat, and a knowledge of the details of naval life. It is not intended that the work at the College shall interfere with sea duty—whose importance is recognized as paramount, both by officers and men. But it is proposed that it shall take a portion of the time of officers between cruises; a time now given to considerable extent to routine occupations, to dock yard service and matters not essentially pertinent to the great object of the existence of the Navy—preparation for and action in war.

In addition to the lectures upon the main subjects of the College, it has been the custom in the past to afford specialists in the different departments of naval activity opportunity and encouragement to communicate the results of their experience to the officers in attendance.

One of the most important of these specialities is that of international law, taught with fullness nowhere else, and whose practical utility to officers of the Navy is daily demonstrated.

There is also immediate practical work to be taken up and continued in the study of the elements entering into naval defense of our coasts and waters, which study is in fact now under way so far as the very scant personnel of the College will allow.

As pertinent to the preceding, the following opinions of eminent officers are given:

Captain Mahan, in the last annual report made by him as President of the College, says: "Having given now seven years to the study of these subjects (naval strategy and naval tactics in their various branches), with my whole attention engaged upon them, and in view of the opposition the College has had hitherto to encounter, I feel warranted and compelled to say that no sustained work has been done, nor is any now being done upon them, except by and through the College. Its claim upon the favor of the Government and Congress depends upon the importance of the subjects with which it alone among the organizations of the Navy undertakes to deal."

In regard to naval tactics, Vice-Admiral Colomb of the British Navy, says: "The science of naval tactics still remains in an exceedingly vague and unsatisfactory state; but the author is now, as ever, persuaded that there are no difficulties in putting it on an absolutely sound basis in peace time. He believes that proper experiments and proper inductions arising thereon are entirely reliable as the foundation of the science; and he has always viewed with alarm the general apathy of British admirals on the whole subject. He trusts it may never be with any of them as it was with Villeneuve on a great historical occasion. 'No doubt,' wrote this unfortunate admiral in August, 1805, 'It is thought that sailing hence with twenty-nine ships, I am considered able to fight with vessels of anything like the same number. I am not afraid to confess to you that I should be sorry to meet with twenty. Our naval tactics are out of date; we only know how to range ourselves in line, and that is precisely what the enemy wishes for. I have *neither the time* nor the means to agree upon another system with the commanders of the vessels of the two nations.'"

Of strategy, Admiral Colomb says: "But the instances I quoted of Nelson at the Nile, and at Santa Cruz, are sufficient to indicate that bravery and strategy combined are very much more powerful

than bravery alone. The brave man had better be intelligently brave while he is about it. It may raise his reputation for pluck to win with great loss; but it will benefit the State more that he should win with small loss. Besides, a man cannot be argued into bravery, and he can be taught strategy."

Of naval history, he says: "In writing this book (Naval Warfare, etc., historically treated) I have kept in mind the double object of showing that there are laws governing the conduct of naval war which cannot be trangressed with impunity; and that there is no reason to believe them abrogated by any of the changes of recent years."

Vice-Admiral Randolph, R. N., says: "Why should there not be a systematic course of practical manœuvres, including experiments in turning under difficulties, in the shortest time and space, in stopping dead from differerent speeds and going astern, etc., through which every executive (line officer) should pass, in vessels of any available size, from steam pinnace to big unarmored ships."

Captain W. H. Henderson, R. N., in a discussion held at the Royal United Service Institution in 1887, as to the study of strategy and war games, spoke as follows: "At the present moment naval officers are feeling most seriously that there is great need for their attention to be drawn to questions of tactics and strategy. Officers present know that their time afloat is occupied in perfecting details of drill, but questions as to the conditions under which we should have to conduct the operations of a great naval war on which we may have to enter any day, and on which not only our naval supremacy, but our maritime power may be at stake, are not seriously thought of. It is all very well to say that naval officers will be equal to the occasion when the time comes, and be able to make up for the deficiencies caused by the neglect of a study of this subject in time of peace. I do not doubt for a moment we shall do our best, but this neglect will entail losses which never should have occured, and will strain our resources to their utmost to overcome, the burthen of which will fall on the nation in sacrifices to a war tribute of blood and treasure unnecessarily large." . . . "We may have the best ships and the best drilled officers and men, yet these advantages will be wilfully scattered to the winds if there is not in the service

generally an exact appreciation and knowledge of the condition under which the naval operations of the day will have to be entered upon and carried out. To attain this means intelligent study and careful provision during times of peace for the exactions of war."

The War College, founded by Rear-Admiral Luce, was earnestly advocated by Admiral David D. Porter, while its value has been impressed upon our own and foreign navies by writings of Captain Mahan, lately its president.

In a printed report, not long since issued from the Navy Department, is the following statement: "The Department is deeply impressed with the importance of the College to the Navy, as a means for insuring the development of the science of naval warfare as distinguished from the development of naval material.

"Both are essential to the full attainment of the results to be expected from a navy. The success of the College in the past has been recognized both in this country and abroad, and its usefulness may be expected to increase in the future."

The following additional extracts from the opinions of distinguished officers on the subject of teaching the art of war are of value.

Captain Hammill, of the English Navy, commenting on the want of naval tactics for our modern men-of-war, says: "What we suffer from appears to be this, that we have no 'school of tactics' whatever in the Navy."

And further on he says: "The only way, in my opinion, in which we can learn modern tactics, is by thoroughly discussing the systems that might be adopted, and by practicing them in peace-time, so that we may be prepared to follow some system in time of war."

J. K. Laughton, M. A., R. N., lecturer on naval history at the Royal Naval College, England, in an address on the last great naval war, includes in his remarks the following: "I fear, a great many of our officers are inclined rather to say, or at any rate to think, that Nelson was no doubt a very fine fellow in his way, but it was a poor way after all. He knew nothing of steam; he never heard of torpedoes. What we have to study now is the application of these; not the obsolete tactics of sailing-ships. Do not, I beseech you, be led away by any such sophistry. Let me impress

on you that the *art of war, like other sciences, is based on fixed principles which never become obsolete; which are the same now as they were three thousand years ago;* and that the exact history of any great commander, the exact detail of any great battle by sea or by land, of any glorious victory or terrible disaster, whether of our time or of any other time is, to the careful student, full of matter for deep and earnest reflection."

Frederick III., in his "Order of Service for the German War Academy," has said: "The object of the War Academy is to initiate into the higher branches of the military sciences a number of officers of the necessary capacity belonging to the various arms, and thus to *enlarge and extend their military knowledge and to clear and quicken their military judgment.*"

Count Moltke, in his "Order of Teaching" for the same Academy, says: "It is, moreover, essential to bring about an active process of mental give and take between teacher and pupils, so as to stimulate the pupils to become fellow-workers. The awakening effects of co-operation like this will never be seen where the one only expounds and the other only listens. But it will naturally be produced by the combination of clear exposition, with practice in the *application to specific concrete cases of the knowledge gained.*"

"Accordingly, . . . the lectures are, as far as possible, to be interspersed with practical examples." . . . "The Academy is not to give fragments of disconnected knowledge."

In his "Order of Teaching," Count Moltke says on the subject of tactics:

"The object of tactical instruction, to which, above all, pre-eminent importance must be attached, is . . . by *teaching and by setting problems to make them familiar with the endless diversity of the conditions of modern battle.*" . . . "The teacher must throughout endeavor to make his instructions suggestive by examples and by exercises on the map and in the open air. In this he will be successful in proportion as he makes use of the experiences of modern and recent wars."

On military history, he has said: "The lectures upon military history offer the *most effective means of teaching war during peace,* and of awakening a genuine interest in the study of important campaigns. These lectures should bring into relief the unchangeable fundamental conditions of good generalship in their relation

to changeable tactical forms, and should place in a true light the influence of eminent characters upon the course of events and the weight of moral forces in contrast to that of mere material instruments.

"These lectures must not degenerate into a mere succession of unconnected descriptions of military occurrences. They must regard events in their casual connections, must concern themselves with the leadership, and must, at the same time, bring out the ideas of war peculiar to each age. They will acquire a high value if the teacher succeeds in bringing into exercise the judgment of his pupils.

"This judgment must never degenerate into mere negative criticism, but must clothe itself in the form of distinct suggestions as to what ought to have been done and decided."

Further on, in the "Order of Teaching," Count Moltke in describing the purpose of all these studies in military history goes on to say: "Before there can be good practice there must be a true theory, and a true theory can be acquired only from historical study, pursued according to a sound method. Moreover, the theory can never have an independent existence; it must always derive its sustenance from fresh contact with the historical reality of which it is the abstract." . . "Historical study which did not yield a theory would be barren and useless."

EXTRACT FROM PREFACE OF CAPTAIN MAHAN'S WORK, "INFLUENCE OF SEA POWER UPON THE FRENCH REVOLUTION."

"The present work, like its predecessor, is *wholly a result of the author's connection with the U. S. Naval War College as lecturer upon naval history and naval tactics.*

"If the commendation bestowed be at all deserved, it is to be ascribed simply to the fact that the author has been led to give to the most important part of the profession an attention which it is in the power of any other officer to bestow, but which too few actually do.

"*That the author has done so is due wholly and exclusively to the Naval War College, which was instituted to promote such studies.*"

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

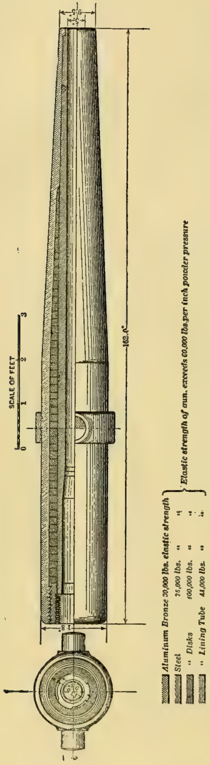
THE WILLSON DISC GUN.

By Lieut.-Comdr. R. R. Ingersoll, U. S. Navy.

The great increase of power due to great increase of initial velocity of the projectile, which has been obtained by the use of smokeless powders in guns which were designed to use brown or black powder, has naturally led to much speculation in regard to the possibilities of the use of smokeless powders in guns constructed to withstand the pressures obtainable with heavy charges of the new explosive. The maximum pressure with charges of smokeless powder, in the guns in use at the present time, is limited to about 16 tons, the same as that obtained by brown or black powders; and the increase of power with these guns is due, mainly, to the absence of a solid residue when smokeless powder is used, giving a larger volume of gas (at the instant of maximum pressure, to expand through the remaining length of bore) than was possible with brown or black powders.

The development of the gun of the present type of construction, by increasing the length of the gun and thus increasing the length of the travel of the projectile in the bore, has a practical limit, for naval guns at least, and the logical development would seem to be in the direction of increasing the resisting power or the elastic strength of the present length, since the proportional increase of velocity, by increasing the travel of the projectile, is small as compared to the possible increase if a safe maximum pressure of 24 tons, say, could be used instead of 16 tons, as is the rule at present with the present form of construction and the present quality of steel when used in the form of masses.

With a maximum pressure of 24 tons instead of 16 tons, veloci-



ties of from 3000 f. s. to 3400 f. s. would be the rule with guns of the present length, instead of 2000 f. s. to 2400 f. s., and the energy of projectiles of the same weight would be more than doubled. The attention of inventors, then, has been directed toward the use of steel in some other form than that of tubes, and successful efforts have been made to utilize the very high elastic strength of steel obtainable in the form of wire or riband.

Mr. Thomas Willson, of New York, the electrical engineer, has invented a process of construction which will allow the very highest grades of cold rolled steel in small thicknesses to be used in building up the gun and which does not involve any of the possible uncertainties of the use of steel in the form of wire or riband. His process of construction has some very novel features, is certainly simple and, so far as it has been tested in the form of a trial cylinder, has fulfilled the expectations of the inventor. The gun built according to Mr. Willson's plan may be described as follows: It consists of a tube of the size and thickness, approximately (extending the whole length of the bore), now used with guns of the ordinary design. Over this tube are shrunk by heat discs of steel of the highest grade (prepared by a process of cold rolling), of an elastic strength of 100,000 lbs. per square inch, a

value which steel makers will contract to furnish. These discs are shown in the plates, and may extend, if considered necessary, all the length of the gun tube to the muzzle. These steel discs, together with the gun tube, are designed to resist the principal stress produced by powder-pressure, that of hoop tension. The elastic strength of the gun in this direction being limited to the elastic strength of the steel in the tube from compression to extension.

Without going into the mathematical details of computing the elastic strength of such a gun, it may be said of it that an elastic strength of 32 tons per square inch can be obtained by a proper proportion of the dimensions. Thus far, resistance to but one stress has been provided for, and Mr. Willson provides for the other, ***the longitudinal stress***, by an outside jacket of aluminum bronze cast in one piece over the assembled tube and discs.

The success of this method of providing for the longitudinal strength will depend upon the certainty of a sound casting, and upon an assured elastic strength of aluminum bronze of 30,000 lbs. per sq. in., while the elastic strength of the assembled tube and discs must not be materially changed by temperature of the molten bronze in the process of casting. If these things can be assured, then the plan of using an outside jacket of aluminum bronze affords a simple and easy solution of the problem.

Manufacturers having sufficient plant are willing to contract to assure sound castings and an aluminum bronze of the required strength. Steel makers of undoubted responsibility are also willing to furnish a steel for the discs which, after the casting of the outside jacket of bronze, will not show a reduction in elastic strength below the fixed limit of 100,000 lbs. per sq. in., claiming that the effect of the casting of the bronze jacket outside the steel discs will be to anneal them, and not to destroy the high qualities obtained by cold rolling or other processes of working. By experiments with a cylinder of 2-in. bore constructed on this plan, this has proven true. Aluminum bronze has been chosen as the material for the outside jacket, because of the simplicity of manufacture combined with low cost; the outside jacket might, however, be made of steel, in two or more lengths, shrunk over the discs and with a locking band to lock all parts together. The system of construction does not, in other words, forbid the use of steel

throughout, but with aluminum bronze of the proper strength, and a sound casting, the longitudinal strength will be ample.

The breech-plug is housed in a short steel tube which screws over the rear end of the gun-tube in rear of the seat of the gas-check, and which is itself gripped by the outside jacket.

This system of construction, so far as the position of the metals of different strength is concerned, is essentially the same as the wire-wound system, so long advocated by Professor Longridge, of England, and which in principle is eminently sound; that is, to place the strongest metal, or that which will stretch most within its elastic limit, as near to the surface of the bore as possible, utilizing the principle of varying elasticities as well as that of initial tensions.

If it were possible to place the discs at the surface of the bore the strongest possible gun with the metal used would be the result. A tube is a necessity, however, to allow for the rifling and also to prevent the gas from entering between the discs. Each disc is rolled cold from a block of high grade steel, the block being thicker in the middle than at the outside edges, and the effect of the cold rolling, aside from the working of the steel, is to produce a state of initial compression of the interior layers and an initial tension of the exterior layers of the metal in each disc. The same condition is thus produced in a solid state in each disc as must exist in a coil of wire in a wire gun, with the advantage that there are no wire ends to secure, and the difficulty of securing the proper tension of winding for each layer of wire is avoided.

This gun is essentially a weapon designed for high pressures, such as are obtainable with smokeless powders, and is in the line of the rational development of the power of the gun. It is thought also that the gun can be built as cheaply as guns of the present design, and certainly the mechanical features seem to offer no difficulties. The weight of the gun, as compared to the present built-up gun, is not greater than the latter, calibre for calibre.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

COAL CONSUMPTION OF SHIPS OF WAR.

By W. H. Riley, Esq., R. N., Staff Engineer.

[*By permission from the Journal of the Royal United Service Institution.*]

The subject of this paper is, no doubt, of special interest to a large number of the members of the Royal United Service Institution and to naval officers generally, and also, judging from several published criticisms, would appear to have some attraction outside the Royal Navy. Under these circumstances it may not be out of place, and not without some value, to offer some remarks for discussion in this Institution on actual expenditures of coal and circumstances connected with its economy.

In the first place, a brief review will be made of the nature of the services performed by a man-of-war for which coal is consumed, and its effect on the accuracy of measuring those services and the amount of coal expended for their performance.

It is a matter of common knowledge that these services are of a much more varied and irregular character than those performed by merchant steamers. A large first-class battleship, capable of developing a maximum I. H. P. of about 13,000 and a speed of 18 knots, actually on peace duty develops I. H. P.'s which vary from 9000 to less than 900, and speeds from 16½ knots to 6 knots. When a definite passage is made it is often at a varied speed, and, if steaming in company with other vessels, it is necessary for all but the leading ship to continually vary the revolutions in order to keep station, these variations often taking place several times in an hour. The helm also is brought into frequent requisition, affecting speed, revolutions and I. H. P. The continuity of a passage is also often further interrupted by evolutionary exercises,

during which the variation of speed and course is so great that it is impossible to measure the propelling performance.

Besides propulsion there are also several auxiliary services to be performed, comprising distillation from sea water for drinking and washing purposes, and for making good losses of boiler feed; lighting the ship internally by electricity; pumping water from sea for sanitary and cleaning purposes, from double bottoms, bilges and drain receptacles; ventilating and steering ship; compressing air for torpedo work; working guns by hydraulic power; hoisting purposes and driving capstans, all of which, besides forming a varied series, are each in themselves of a more or less irregular character.

As regards propulsion, the variation described renders it extremely difficult to accurately calculate the average power developed. When the revolutions are subject to such frequent alteration, the indicator diagrams will often be taken either when the revolutions are greater or less than the average for the period the diagrams cover; and it is frequently the case that in the interval between taking the diagrams from successive cylinders the revolutions will be changed, thus giving not only unfair but inconsistent results. The principal sources of accurate data are the comparatively rare occasions when the vessels happen to be steaming independently over long distances. It must be borne in mind, however, that the results so obtained may differ considerably from the results obtained when making a passage under the varied conditions noted previously, although in the two cases the average speed of passage may be the same. When steaming irregularly a very rough approximation to the I. H. P. can be obtained by calculating the average revolutions per minute, and taking the I. H. P. corresponding to this as determined on the measured mile trials; this, however, is open to the objection that nothing is allowed for differences in the state of the weather and the ship's bottom, which circumstances are found to have a considerable effect, the exact amount of which is difficult to determine. In some few cases the conditions as to weather and bottom may approximate to those under which the measured mile trials were made, when fairly reliable results as to average I. H. P. may be obtained in this way.

The amount of work done by the auxiliary engines and appliances is generally impossible to absolutely measure. Some of

these engines are fitted with means for taking indicator diagrams, and so enable the I. H. P. developed at a given time to be calculated; but their work is generally of such an intermittent and varied character that this would afford no measure of the average I. H. P. developed. A very fair estimate of the services rendered by the electric lighting engines and the distillers can, however, be otherwise determined, the current generated by the former being measurable by electrical appliances, and the water made by the latter by the capacity of the tanks into which the fresh water for drinking and washing purposes is delivered. The other services are of such a character that they can only be valued by the amount of coal they require to perform their usual daily work.

A few remarks will now be made upon the degree of accuracy with which the coal consumed can be measured and apportioned to the several services for which it is used. The ordinary method of measuring the coal taken out of the bunkers is to fill buckets of known capacity and to record or "tally" each as it passes from the bunkers into the stokehold; one of these is occasionally weighed, both empty and when filled level with the top with coal, the difference giving the weight of coal per bucket. Of course this system of measuring in detail is open to several sources of error, such as when the buckets are not all filled to the same height as those which have been weighed, or when every bucket is not recorded; and also any inaccuracy in the weighing machine, or from clumsiness in carrying out the operation, will be multiplied when the weight so obtained is taken as the standard for several. It is customary, in some ships, to allow a small percentage on the expenditure so obtained, to avoid a greater quantity being used than is recorded; it is, however, often found that this percentage need only be very minute when the staff has been well trained in coal tallying, and is made to understand the importance of accuracy.

As a check on this method it is the common practice to measure the capacity of the coal in the bunkers; this being an especially accurate method when steaming sufficiently long to have completely emptied one or more bunkers after having been filled. Of course, for this to be accurate, it is necessary that when the coal is taken on board, the bunkers should be evenly trimmed up to the deck beams; this practice, having also the advantage of taking on

board the greatest quantity of coal, justifies the extra time taken during coaling to insure it being done.

It has been suggested that the draught of water of the ship affords an accurate means of measuring coal expenditure; no doubt this would be so if care and trouble were taken to measure the quantity consumed of other stores, and if the ship were floating in absolutely smooth water when reading the draught. The practice is frequently adopted at government coaling depots, the coaling lighters used there being filled in places where the water is generally smooth and the calculations not confused by the weight of any other stores. The method is hardly necessary in ships, as the two first alluded to should be sufficient to insure a fair degree of accuracy.

It is an important point to apportion the amount of coal used to the several services, and in some cases it requires a considerable amount of patience and trouble to attain this end. The advantage obtained, however, is worth the trouble, as in cases of high expenditure it enables the cause to be better traced.

Several ships, including all the more recent, have either an auxiliary boiler or one or more of the main boilers specially fitted for the purpose, which can be connected up only to the usual main lead of auxiliary steam-pipe which supplies steam to all the auxiliary machinery. Thus the main and auxiliary machinery, although working concurrently, can be worked independently, and the coal expended for each readily determined. The amount required for each auxiliary service presents greater complications, but can be approximately obtained by having only one at a time in operation for a sufficient period to enable the coal used to be properly measured. These individual results added together will give a greater total than is obtained when all the auxiliary engines are in actual operation together, as the coal required to make good the losses by radiation from the boiler and steam-pipes will have been added together several times in the former case, but should only be taken account of once. It can be practically determined from the above data, and can be further checked, if an opportunity occurs, by stopping all the engines and noting the coal required to maintain the working pressure in the boiler and steam-pipes.

When no auxiliary boiler or main boiler specially fitted for sepa-

rately supplying the auxiliary services is fitted, the coal required for most purposes can be determined when in harbor, and, by subtracting an estimate formed on this basis from the total expenditure when under way, that for the main engines is obtained.

Another method is to note the difference in the daily expenditure under way at low speeds (1) when a particular auxiliary engine is at work, (2) when it is stopped, all the other circumstances being as nearly as possible the same in the two cases. As, however, the disproportion between the total daily expenditure and that for one auxiliary engine is considerable, the trials should be repeated three or four times to obtain reliable results. That this system can be fairly accurate is proved by the fact that separate similar ships have obtained in this way approximately the same expenditures. A modification of this method is to note the difference between the I. H. P. developed in cases (1) and (2) when the daily expenditure of coal is the same. Knowing this difference and the coal expenditure per I. H. P., an approximate measure of the coal required by the auxiliary engine in question may be obtained. Special care must be taken in the measurement of the I. H. P., and the trials should be repeated three or four times.

By adopting one or the other or all the above plans, vessels can approximate very closely to the expenditure for the main engines and to that for the auxiliary engines as a whole or in detail.

Besides the above expenditures there are also some others which it is necessary to distinguish from them to avoid confusing comparisons, and which are, therefore, separately accounted for. They include laying fires and raising steam, banking fires, waiting orders and steaming when the speed is so variable that no distance can be logged, as when at target practice; there is not much difficulty, however, in measuring the coal so used with fair accuracy.

Some instances of coal expenditure by warships under certain circumstances were given by Admiral Long in his paper on Cruisers, read in the early part of this year at the Institution of Naval Architects. The following is one of a different character, showing a six months' expenditure incurred by a large modern battleship on ordinary peace service :

	Tons.
Steaming, making good distance	869
Laying fires, banking fires, steaming when no distance is logged, etc.	335
Culinary purposes and warming ship	112
Distilling for ship and boilers	481
Electric lighting	544
Other auxiliary purposes, as steering, pumping, working guns and torpedoes, ventilating, workshops, etc.	211

These services comprise four short passages of about 70 knots each and one of about 500 knots at moderately steady revolutions per minute; one passage of 500 knots at revolutions varying from 61 to 97 per minute, this including quarterly passage trials; 14 days' cruising at from 4 to 12 knots over 2000 knots, with occasional stoppages; three occasions specially under way for target practice; one electric light engine in use constantly throughout the whole period, generating a current of from 260 to 410 amperes; a second electric light engine in use occasionally a few hours at a time; 1950 tons of water distilled for ship purposes; and the usual ventilating, pumping and other minor auxiliary machinery in daily use.

During war service the expenditure would probably be much increased, but would entirely depend on the service required. If called upon to steam long at high rates of speed, the increase would be very great, and coaling would have frequently to be resorted to. It would also be increased, but not nearly to the same extent, if called upon to steam for long periods at a low speed; as this is a very probable demand that will be made, the question is considered in some detail later on.

We now proceed to an analysis of the several services in greater detail, and begin with the main engines, whose object is the propulsion of the ship. The coal expended and power developed by these engines have been determined, in most ships, from definite experiments for the purpose, as well as from the ordinary occasions on which a steady speed has been maintained. The performance in a particular case may be given, that of a large battleship, as very full and reliable data have been obtained under definite conditions, and the engines are representative of a large number of

recent construction. The following are the expenditures of coal per hour per I. H. P. :

Percentage of full designed power.	Coal per I. H. P.
55	2.03 lbs.
28	1.82 "
22	1.93 "
14	1.76 "
7	2.2 "

There have been more economical results than these, at some of the powers, from engines of the same type, and also some worse, the expenditure being materially affected by several circumstances such as quality of coal, differences in details of construction, and differences in management. The above figures, however, may be taken as a fair performance under good conditions.

The engines of the ship in question are of the tri-compound type, which, in the Royal Navy, is the most advanced type of engine. Its principal characteristic is economy of fuel, and its adoption has been found to have reduced coal expenditure for power both at high and low powers to about an average of 20 per cent. below that required by bi-compound engines, and about 50 per cent. less than that required by simple engines.

The advance of the boilers with regard to the economical generation of steam has not kept pace with the engines in the economical use of steam; their advance has, however, been very marked in enabling the high pressures required by the later engines to be safely obtained. The old, roomy, rectangular, low pressure boiler of 30 lbs. per sq. in. enabled a large proportion of heating surface to be introduced, facilitating the passage of heat from the fire to the water, and also large furnaces and combustion chambers which allowed the fuel to burn completely and give out a large proportion of the heat it was capable of generating. The cylindrical forms necessitated by high pressures, now up to 155 lbs. per sq. in., curtailed to some extent these constructive features, and hence there was some falling off in the amount of water evaporated by a given quantity of fuel. It has, however, been found possible, in some of these boilers, to get a high degree of economy. At moderate powers, rough measurements made on

board H. M. S. Thunderer showed an evaporation of 9.6 lbs. of water per pound of fuel burnt, which was very good Welsh coal. There is no doubt, however, that such a result requires both very good coal and careful stoking. The temperature of the feed water was about 100° F., and the boiler pressure 110 lbs.

To obtain the best results from the steam, it is necessary that the cylinders should be steam jacketed. Steam jackets are not only of value in this respect to the tri-compound engine, but also to the bi-compound and simple engines when even a moderate rate of expansion takes place in each cylinder. The fitting is generally adopted in the Navy, and consists of an annular chamber, enveloping the cylinder into which steam is admitted and maintained at a pressure about equal to the maximum acting inside the cylinder itself. This, by imparting heat to the expanding steam, aids in reducing the amount of steam liquefied. The benefit derived from these fittings depends upon circumstances, but it has been clearly shown that the amount of power developed by a given expenditure of fuel can be increased 10 per cent. by their use. In practice, the pressure in the steam jackets must not be so high as to avoid all liquefaction on the cylinder surfaces, as these surfaces, when working too dry, require a larger amount of oil to keep them efficiently lubricated. The objection to this is that a considerable quantity of the oil so used passes with the working steam into the feed water, and thence to the boilers, and increases the temperature of the heating surfaces. With this limitation, however, steam jacketing has proved of economical value.

A very important point, peculiar to the engines of a war-ship, is economical working at reduced speeds, and this point will be dealt with somewhat fully. The previously mentioned battleship averaged, on the runs made during six months, a speed of 8.6 knots, which is above the average of most other vessels. This speed corresponds to an I. H. P. of 1300, smooth water and clean bottom; the actual average I. H. P. would be greater than this on general service. The "ordinary speed" of such a vessel is 9½ knots, corresponding to 1800 I. H. P., and the most economical speed would probably be near 7 knots, 900 I. H P.

The low average speed is partly the consequence of the greater distance made good per ton of coal at low speeds than at high speeds, and partly because the nature of the general service does

not demand a high speed. The cause of the increased economy for distance at low speeds is, no doubt, well understood, and all that need be done here is to draw attention to some of the sea speeds and consumptions determined at sea in the battleship in question, and which are as follows:

I. H. P.	Speed.	Revolutions per minute.	Coal per day, tons.	Knots per ton of coal.
7,220	13.66	83.6	157.5	2.08
3,600	10.9	68.1	70.4	3.7
2,870	9.92	62.0	59.6	4.0
1,810	8.96	54.2	34.3	6.2
900	6.77	41.2	21.6	7.5

The knots made good per ton of coal show the superiority of the lower speeds in economy of fuel, this arising from the high rate at which the power increases in comparison with the increase of speed.

An important point in connection with this question is that if the speed be reduced below a certain point the distance covered by the expenditure of a ton of coal decreases. The speed at which this change takes place is termed the "most economical speed," and is of service when the chief consideration is to steam the greatest distance for a given quantity of coal. It is always a very low speed; is rarely higher than that corresponding to 12 per cent. of the full forced-draught I. H. P., and in some vessels which have a very large proportion of power for their displacement the I. H. P. for most economical speed is a much lower proportion.

The nature of this speed and the circumstances affecting it can best be examined by means of a diagram, which is given in Fig. 1. The horizontal line OX represents the speed in knots per hour on the number of revolutions made by the engines per minute; the vertical line, quantity of coal expended in tons per day; the curve AE represents the expenditure of coal per day for any particular number of revolutions or speed. To construct this curve a number of actual runs must be made at various speeds, and the coal expenditure carefully measured in each case; the points representing the results are plotted off on the diagram, and a fair curve drawn through them. It will be found that a peculiarity of this curve is that if produced to the zero speed it will

cut the line OY at some point, C, some distance from O, the distance OC representing the expenditure necessary to counteract the effects of radiation of heat from engines and boilers. The most economical speed and the consumption are represented by the point E, where the tangent drawn from O touches the curve AE, OD representing the speed and DE the consumption. That this is so follows from the consideration that the most economical speed must be that where $\frac{ED}{DO}$ or $\frac{\text{expenditure}}{\text{speed}}$ is least. This value is constant for all points on the line OE, and is greater for all points above OE; that is, all other points on the curve AE represent a higher consumption for distance than the point E. One value of this method is that it is readily seen that for a wide range of speed about E the increase in expenditure is very trifling, the present figure showing that the speed may range from 30 to 60 revolutions, or 4 knots to 7½ knots, without any considerable variation in the economy. In practice, it will generally be more desirable to steam at the higher speed, viz., 7½ knots in the case considered, and this may be done without incurring any appreciable waste of fuel. The most economical speed varies with altered circumstances of weather, but when a series has been obtained under definite similar conditions they may be plotted out in the same way.

Also, in cases where it is necessary, with a given amount of coal on board, to steam the greatest distance with it, the coal used for the necessary auxiliary services must be taken into account, and can be represented on the diagram by drawing a line, distant OY, equal to the auxiliary expenditure per day. The "most economical speed" must be obtained by drawing the tangent to AE through the point Y, which gives a speed greater than that obtained when the auxiliary services are not taken into account.

If this coal curve be closely examined in comparison with the I. H. P. curve, one or two important points will be noticed. Starting from the higher speeds, the I. H. P. curve falls rapidly as the speeds decrease until low speeds are reached, when the fall is less rapid, and at very low speeds indeed approach the direct proportion to the speeds as the influence of the constant engine friction becomes predominant. At high and moderate speeds, the

coal curve approximates to the power curve, but falls less rapidly at the lower speeds, being affected by the amount of steam necessary to overcome the back pressure on the low pressure pistons and by the heat lost by radiation, the former being practically constant at all speeds and the latter constant if the same number of boilers be in use. These two sources of waste play an important part in increasing the quantity of steam used per I. H. P. at low speeds.

To reduce the rate of this increase as much as possible is one of the considerations that has led to the adoption of a lower ratio of volumes of the low and high pressure cylinders than is the practice in the merchant service, although this entails some sacrifice of economy at the higher speeds. The case quoted will show that a high degree of economy at even very low powers can be obtained from such engines. The proportion of cylinder volumes adopted for tri-compound engines of war-ships averages, about, high pressure, 1; intermediate pressure, $2\frac{1}{4}$; low pressure, 5; while for similar engines of merchant ships it is not infrequently 1, $2\frac{3}{4}$, 7.

To obtain the best results at low powers, it is most essential that the reduction of the power should be obtained, as far as possible, by increasing the rate of expansion, thus supplying the steam to the high pressure cylinder at a high pressure and cutting off the supply at an earlier part of the piston's stroke; the jacket pressures, within the limits already referred to, being so adjusted as to avoid unnecessary liquefaction. When steam at the full boiler pressure is admitted to the cylinder and the earliest practicable cut-off employed, the engines still develop a comparatively high power, and any further reduction must be effected by throttling the steam or reducing the pressure in the boilers. The latter is the preferable plan, but cannot be reduced below that necessary to promptly handle the main engines and to work the auxiliary engines.

As an illustration of how the advantages peculiar to a more advanced type of engine may be lost, the indicator diagrams in Fig. 2 are given. These are combined in the simplest way for the sake of a more ready comparison, and represent one set of three from a tri-compound engine, 130 lbs. boiler pressure, and one set of two from a bi-compound engine, 60 lbs. boiler pressure, both

engines working at about 60 per cent. of their natural draught power. The difference between them is chiefly that a much later cut-off in the high pressure engine was adopted with the tri-compound engine, resulting in reducing the total ratio of expansion to less than in the bi-compound engine; there are also evidences of greater liquefaction. The tri-compound area, which represents the work done per stroke, is rather greater than that of the bi-compound; but the quantity of steam used, as indicated on the diagrams, is also as much greater as to make the economy of steam practically the same in each case, while the actual consumption of fuel per I. H. P. was slightly greater with the tri-compound. This engine, when worked with an earlier cut-off and steam in the cylinder jackets, has a substantial advantage in economy over the particular bi-compound engine referred to.

In the Blake and Blenheim, whose engines are designed to develop exceptionally high powers, special arrangements have been made to keep down the coal expenditure at very low powers, and consists, as is generally known, in fitting two separate sets of engines to each of the two propeller shafts. In peace-time, it was intended that the forward engines should be disconnected, and the two after ones alone used. Thus, when steaming at a comparatively low rate of speed with the after engine only, the proportion of the corresponding I. H. P. to the full power would be half what it would be if all the engines were in use. From experience with the Blake under the two conditions, the consequent reduction in coal expenditure per knot at 9.6 knots has proved to be substantial.

In some ships the maximum power of the engines during peace service has been reduced by fitting a special slide valve with increased lap to the high pressure engines, the eccentrics being suitably adjusted. This arrangement has only been applied to some recent ships, and sufficient experience has not yet been obtained to show the effect on the economy of steam.

With regard to adapting the boilers to low speed steaming, the subdivision into several boilers, necessary in most ships from other considerations, enables the boiler power to be properly proportioned over a large range to the actual power to be developed by the engines. The usual conditions of men-of-war steaming, however, render it generally necessary to have steam up in a greater number of boilers than is required to develop the average I. H. P.

economically, as the variation in revolutions and auxiliary work above referred to demands that steam should be quickly available for the maximum requirements. This not only increases the waste arising from radiation, but also from the irregular firing necessary to meet the varying demands of the engines.

When the number of boilers in use is much above the average requirements of the engines, and the maximum is not wanted to be exerted too suddenly, recourse is frequently had to the reduction of the grate area. This, by increasing the proportion of heating surface to grate area, and by affording a larger space for the combustion of the coal gases, tends to greater economy. This reduction of grate can be readily effected by allowing the back bars to become clinkered over, or, in some cases, the service renders it possible to brick over these bars; vertical plates have also been used, placed in the ash pits transversely so as to prevent air having access to the length of fire bars behind, and have been found to be beneficial in some cases.

It has often been suggested that, at low powers, the use of only one engine and screw of a twin-screw ship might be more economical than using both engines. This has been tried by many ships, with the result that, down to powers as low as 10 per cent. of the natural draught power, there is no saving of fuel, and often a substantial loss. These show that the falling off in speed caused by the resistance of the rudder and idle screw is so great as to more than counteract the increased efficiency produced by developing the whole of the power in one engine, and the reduced waste caused by the elimination of the engine resistance and back pressure of the engine which is stopped. In most of the trials the idle screws were not disconnected from the engines, but, if they had been, there is sufficient experience to make it probable that they would not have revolved at that power, and the practice is also open to the strong objection that the control of the ship is seriously impaired. An average result from a battleship may be quoted, where the one-tenth I. H. P. was 900, the speed with two screws 6.8 knots, the speed with one screw 5.3 knots, the distance made good per ton of coal with two screws 7½ knots, and that for one screw 5¼ knots. The percentage of loss was therefore 30, and a reduced speed of 1½ knots into the bargain. At higher speeds the single screw method is still more unfavorable.

There have been a few cases where some economy has been obtained at from 3 to 5 per cent. of the natural draught power, due apparently to the circumstance that at extremely low powers the inefficiency of the engines rapidly increases. The corresponding speed is, however, so low that it may be doubted whether it would prove of any practical value. Even at these low powers it would appear that the economy is largely dependent upon conditions of weather, and if economy were proved in a given ship under certain circumstances, it would probably disappear if the circumstances were even slightly altered.

A proposal has been made to disconnect the L. P. cylinder of a triple-expansion engine at low powers, and thus develop a higher proportion of full power, say 30 per cent. in a bi-compound engine of cylinder ratio 2¼ : 1, instead of 20 per cent. in a tri-compound engine of double that ratio. This proposal is based, however, on the supposition that the loss of efficiency of tri-compound engines is very great at low powers; but experience generally in the navy engines, including the example already quoted, shows that, over a wide range of power, this is not the case; and that the coal expended per I. H. P. when using all three cylinders is materially below that of a bi-compound engine having a comparatively low ratio of cylinders, although the low power developed is in a somewhat higher proportion to the full power in the latter case than in the former. This difference in coal per I. H. P., in favor of working with three cylinders, is also found to be sufficient to counteract the loss sustained by the engine friction of the L. P. cylinder, and thus leads to the conclusion that no economical advantage is to be gained by the adoption of the proposal under consideration.

An instance of some interest may be given, although it only indirectly bears upon the question. It is, however, a case where a comparatively low power was developed with a cylinder ratio reduced to half the total ratio of the complete engine. The vessel referred to had bi-compound engines of the three-cylinder type, one H. P. and two L. P., the total ratio of volumes being 3.72 : 1. One of the L. P. engines became disabled, and the ship steamed 6000 knots at about ¼ power with only one H. P. and one L. P. cylinder, the ratios being then 1.86 : 1. The practical result was a coal expenditure per hour per I. H. P. of 3.5 lbs. against 2.4 lbs. when all cylinders were in use, developing the same power. Indicator

diagrams to show the distribution of steam when using two cylinders are given in Fig. 3, and also, for comparison, a set when using about the same quantity of steam per stroke when all engines were in use. These show that part of the increased coal expenditure was due to increase of back pressure, due apparently in some measure to the whole of the steam entering at one end of the condenser; but, making an allowance for this, the expenditure of steam was much greater than when using the whole of the engines.

The coal expenditure for auxiliary purposes is a very material item in war-ships compared with the quantity used for propulsion. In the course of a year the larger modern ships generally burn as much (or more) for the first as the last; this is partly absolute, on account of the increase in the number of auxiliary services for which coal is used, and partly relative, on account of the low average speed and time under way, as compared with a merchant steamer. The proportion becomes considerably lessened in the case of a passage at a fairly high power, say at half the full power, the proportion between the coal for auxiliary services and that for propulsion being then about 9 per cent.

To afford an idea of the magnitude of the auxiliary engines on board a modern ship, it may be stated that on one of the most important there are 58 distinct engines, not including boat engines, the I. H. P. amounting in the aggregate to quite 2,000. This, if continuously developed, would mean an enormous expenditure and considerably beyond what is actually incurred. As a matter of fact, several of these engines are only duplicates of others, and would not be used at the same time with them; and many are only used intermittently.

It should be mentioned here that the auxiliary engines here referred to are only those which are used for purposes distinct from propulsion. The coal expenditure for such engines as the main circulating engines, main feed engines, and starting engines is included with that for propulsion. Many of the auxiliary engines do not lend themselves to economical working, as some are necessarily so far removed from the source of steam that considerable condensation takes place in transit, also they receive their steam supply at a reduced pressure and exhaust it against a comparatively high pressure. The work of some is of such a

character that it is impossible to employ any material degree of expansion or to compound the cylinders. To obtain the greatest economy possible, those which can be so treated are compounded, and also a separate auxiliary boiler is fitted where one of the main boilers is too large for the work; or, in some cases where the main boilers are of the double-ended type, for one of these, two single-ended boilers have been substituted.

The electric light engines deserve special consideration, as one or more are in use in many ships practically all the year round, and necessitate, consequently, a considerable total expenditure of coal. These are now made, and have been for some years past, on the compound principle, and a very early cut-off employed in the high pressure cylinders, thus allowing of a high total rate of expansion. Every engine is tried carefully at a government dockyard to determine the quantity of steam it consumes, and a certain standard of economy must be attained. These trials afford some useful facts as to their consumption under the trial conditions, but, as will be supposed, this will be subject to some modification when in use on board ship. On these trials no account is taken of the steam used by the feed pump, or of the condensation which takes place in long leads of steam pipe, nor of the amount of coal used when fires are cleaned. With regard to the condensation in steam pipes, it is found on the trials on shore of the electric light engines that an amount of water is collected at the engine end of the supply pipe to the extent of 7 to 13 per cent. of the total steam used, although the length of pipe is comparatively short and is well lagged.

A case of the expenditures on board a battleship and on trial in the dockyard may be quoted; the steam consumption on trial was found to be for one electric light engine generating a current of 400 amperes such as to require a daily expenditure of 2.6 tons of Welsh coal of good average quality. The reported expenditure from the ship is 3 tons per day; and the number of lights in use such as to require from one-half to the full power of one engine. The case of the Warspite, 8400 tons displacement, especially mentioned by Admiral Long in his recent paper, showed an expenditure for lighting on passage out to her station of over 4 tons per day. This amount was perhaps larger than that really used, insufficient opportunities having occured to enable it to be accu-

rately determined. Later results showed an expenditure of about 3 tons and less per day, a reduction probably assisted by economy in the number of lights and length of time in use. The reduced expenditure, however, does not appear excessive when it is considered that the engines are of the simple type.

Distillation of sea water is also an important item of coal expenditure. On a large ship fresh water is often required to the extent of about 12 tons per day for drinking, cooking and washing, and about ¼ ton of water per ton of coal burnt in the boilers to make up losses of steam and water from the boilers, engines, pipes, joints, valves, etc. Both of these amounts are of a very elastic nature, and in many cases it has been found possible to materially reduce them below these figures. When direct distillation from the boilers was employed, as in the older ships, a very fair return was obtained for 1 ton of coal, averaging about 7½ to 8 tons of fresh water. When, to avoid large quantities of scale being deposited in the boilers, double distillers were adopted, the quantity of fresh water obtained for 1 ton of coal was reduced to about 5 to 5½, the loss resulting principally from condensation of primary steam on its way to the evaporator and to the high temperature it possessed when escaping as water from the evaporator. Compound double distillers were tried and found to result in a considerable gain in the quantity of water produced for a given expenditure of fuel, and in recent ships a pair of double distillers is so fitted that they may be worked in this way. It is arranged, however, that each distiller can be worked separately when urgency requires the greatest output to be made. It may be said here, in connection with this point, that it not infrequently happens that economy of fuel and economy of weight and space do not go together, and hence, in a man-of-war, where economy of weight and space is of such importance, economy of fuel must often to some extent be sacrificed.

Under some circumstances of naval work, economy of coal may be of such importance that, beyond working the machinery so as to fulfil its services with the least expenditure of coal, it may be desirable and possible to dispense with some of them altogether. The character of the work must determine which of them can be dispensed with, but those which appear to lend themselves to this are the steering and electric lighting engines. Both of these use

up considerable quantities of coal, which can be saved for other purposes by steering with the hand gear and using oil and candles for lighting purposes.

The exact advantage to be gained by this course depends upon the service, and is greater the slower the rate of speed. A large cruiser, say, carries 1000 tons of coal; at 10 knots speed under good conditions this will carry her, with all the ordinary auxiliary purposes in use, about 7700 knots; if the steam steering and electric lighting engines be stopped, she will be able to cover about 8700 knots, a gain in distance of 1000 knots, or $\frac{1}{8}$th more. At a high power, say, 60 per cent. of the natural draught, she may steam about 3000 knots in the one case, and 3100 in the other, the gain in distance being only 100 knots or $\frac{1}{30}$th more.

Before concluding this paper, the progress of the coal question may be illustrated by giving some particulars of the passage of three vessels, fitted with progressive types of machinery, out to the same distant station. The first had simple engines and very little auxiliary machinery, and steamed the distance of 7082 knots at an average speed of 5.5 knots; 1575 knots were made under steam only, 5071 under steam and sail, and 436 under sail only; the total coal expenditure was 1046 tons. The effect in this case of using sail power when steaming, besides increasing the speed $1\frac{1}{2}$ knots, was to reduce the coal expenditure per knot to less than one-half what it was when the vessel was under steam only. The second vessel had bi-compound engines, boiler pressure 90 lbs. per sq. in., was fitted with a large amount of auxiliary machinery up to modern requirements, and steamed 6985 knots at an average speed of 7.7 knots, with a total coal expenditure of 1533 tons; this includes a considerable fraction for the main engines for purposes other than making good distance. The third vessel, a new ship, it is estimated from actual experience with similar types of engines, triple-compound, 155 lbs. steam pressure, will steam the distance of 7000 knots for 1200 tons of coal at an average speed of $12\frac{1}{4}$ knots. To afford an idea of the comparative power to propel these ships, it may be stated that the H. P.'s required to drive them at 10 knots per hour are respectively 1500, 1500 and 1350, smooth water and clean bottoms.

The first two cases showed a very material reduction in the coal expenditure for power developed in favor of the bi-compound

engine; but the total amount of coal went up considerably. This is almost fully accounted for by the facts that she had no help from sails, steamed at a higher average speed, and had a greatly increased amount of auxiliary machinery in use. The expenditure for the tri-compound engines should show a still further economy for work done, but it is not likely that the total expenditure will fall below that of the ship fitted with simple engines, on account of the very much larger amount of work to be performed by the machinery.

A review of some of the remarks in this paper will show that much has been done in the construction of the machinery of war-ships to enable economy of fuel to be obtained, but that the realization of this economy depends materially upon its use and treatment on actual service. So great is the influence of the latter, that improved treatment has been known to have nearly doubled the radius of action of a vessel that was obtained when the treatment was not so satisfactory. Some difficulties in the way of economical working have been considered, and it has been shown that the principal of these can be overcome to such an extent as to obtain good results on actual service. Many of these difficulties are such as to be out of the control of officers in charge of the machinery, and it is in these respects that officers in command of ships may exercise material influence on coal expenditure, especially in such matters as economy in the use of auxiliary services and in steady running, and generally in the encouragement of those under them to use every effort to keep down expenditure to the lowest limit consistent with efficiency.

The following are some extracts from the discussion:

MR. WINGFIELD: I have been very much struck with the ingenuity of the diagrams, which are entirely new to me, showing a very simple method of finding out from a series of trials the intervals between those experiments at which the ship would be steaming at the most economical rate. Diagrams are always more satisfactory for taking averages than simple arithmetic. You may approximate by an ordinary average, but if the experiments are reliable, you can get the absolutely correct point by means of a diagram, and I must congratulate the author upon the very ingenious arrangement that he has hit upon. Mr. Barnaby has just informed me that an American engineer, Mr. Hollis, has pointed out that there are two speeds at which the same economy is realized, and I see this diagram also clearly shows this to be a fact if the ship is not run-

ning at precisely the most economical speed. For instance, if the engines are running at 20 revolutions, the coal consumption is shown on the figure by $E'D'$.* A line drawn through O and E' will, if produced, cut the curve again at E'', which is perpendicularly above 80 revolutions on the scale. The author has pointed out that, at any point on such a line as this, you are burning the same coal per nautical mile, hence a given distance can be run by the ship whose performance is represented by this diagram, with the same weight of coal, whether running at 20 or at 80 revolutions. That is, the distance will be done in one-fourth the time at the higher speed, without any larger expenditure of coal. It is evident, then that, if not quite sure what is the most economical speed, it is better to err on the fast side rather than on the slow, and, when cruising, orders should be given to run as near the economical speed as possible, but never at a *less* speed unless circumstances require it. Whenever a ship runs at a speed less than that of maximum economy, she is wasting time as there is another higher speed of equal economy. I think the great importance of this fact is self-evident. The coal per nautical mile $= \frac{DE}{24DO}$; as the triangles $D'E'O$ and $D''E''O$ are similar, it is evident that, as stated above, all points, such as E', E'' on the slant line, represent equal weights per nautical mile, or equal radii of action for a given weight of coal burnt. The distance run per ton of coal is, of course, $24\frac{OD}{DE}$.

MR. WHITE: The concluding sentences of this paper sum up the lessons which should be learnt from its study. The paper will be of enormous value to the service afloat. It is not merely a remarkable collection of illustrative examples of causes affecting coal expenditure, but contains also very valuable suggestions as to means whereby economies may be effected. Mr. Riley has made this matter one of the closest study. The paper will be circulated throughout the fleet in the Journal of this Institution, and I believe that it will lead to considerable practical benefit both to the service and outside the service. When we have it shown that by means of greater skill or experience in management the radius of action for a given coal supply may be doubled, we can see how important it is that both officers in command and those in charge of the engine-room staff shall know in what direction to work in order to obtain economy. Mr. Riley does not make speculative statements, but deals with records of fact. In the same ship, at different periods of service, he shows that the radius of action has been doubled by savings due to better management alone. If I may venture to emphasize the statement made by Mr. Riley, I should wish to dwell upon the increased expenditure which may be involved in rapid variations of speed, or in uncertainty as to speed, or in

* A figure illustrative of Mr. Wingfield's remarks will be found in the accompanying plate.—EDITOR.

the extended use of auxiliary services of various kinds. Sensible economies in coal may be effected by commanding officers if they set themselves the task of assisting engineer officers as much as possible. When I was afloat in the manœuvres of 1889, I made as close a study as I could of the conditions obtaining in a squadron on service. In that division of the fleet in which I was embarked, when we were at steam tactics at 8 knots, every ship had steam ready for at least 10 knots. Sometimes, in watching the manœuvres, I found ships were moving for a time at as high a speed as 12 knots in order to keep station. But the average speed of the tactical movements was only 8 knots. Clearly, such a command of steam and speed is absolutely necessary when a fleet is performing evolutions. Mr. Riley has well pointed out that there are conditions of service when considerations of economy in coal expenditure must give way to other considerations. But when a vessel is proceeding independently on a long voyage, by suitable arrangements much may be done in the way of coal economy. Take the illustration Mr. Riley gives of what may be done by stopping the electric light, or the steam steering. The latter plan, of course, involves some more manual labor, but I have been more than once on board a battleship which was steered with perfect ease and success in making a passage by manual power. To show what can be done, I may add that in the case of the Blake or Blenheim the ship was steered by hand up to a speed of 18 knots. It is much more convenient, no doubt, to have one or two men only at a steam steering wheel, rather than many men at the hand steering wheel. But if economy of coal in making passages is aimed at, then in these, and in many other ways which Mr. Riley has hinted at, very much may be done.

Admiral Colomb: There are one or two matters I am reminded of, for instance, the economy of using one of two screws. I do not know whether Mr. Riley has data to show how the economy of using a single screw varies according to the direction of the wind. I do not know how it may be with the more recent classes of ships, but with the older classes of twin screws that I had to do with it was almost invariably found that when the wind blew 3 or 4 points on the bow, the economy of using the weather screw rose considerably over what the use of one screw did, for instance, when the wind was right ahead. The effect of the change of wind in that way was to require the ship, supposing she had been using the two screws, to carry rather more weather helm. The use of the single screw effected the purpose which so much weather helm did, and the consequence was that with the single screw you were able to keep the helm more in midships. I hoped that we should have had in the paper some remarks on matters which have been a good deal before us recently—strongly before us in Lord Brassey's Naval Annual this year. I mean the vexed question of the effect of auxiliary services on the radius of action. Complaints are raised, I do not think myself properly raised, that the

radius of action given in the tables represents a greater radius than really exists on account of the auxiliary engines. But it seems to me that what is wanted in the service is some sort of factor, some sort of divisor which would discount the figures given, which I understand have simply to do with the powers of propulsion of the engines without taking anything else into account, that if, corresponding to the different classes of ships, some discounting figure could be given, it would be always easy to tell at once what amount of deduction must be made from the nominal radius of action. I very much agree with Mr. White as to this paper being of the greatest possible value to the service. I told my friend, on entering, that I had read the greater part of it, and that it was a paper which could not provoke much discussion in this theatre, but that it certainly would provoke in the service a great deal of useful thought. I am glad to hear Mr. White attack the too great use of machinery on board ship. Where man-power is capable of doing the work I cannot help thinking it is very much better on board warships that the man-power should do it. I used to be made very low in my spirits with watching the machinery weighing the anchor when there was plenty of man-power to have done it, and the mass of man-power was looking on idly at the machine. In the same way with steering. It would be better for the service if machinery should only be used for those purposes for which it is absolutely necessary, and that we should fall back on the muscular power which we are bound to have on board for fighting purposes so far as it can possibly be used.

Mr. Liversedge, R. N.: I should like to point out a means of testing the accuracy with which coal has been measured. Suppose the H. P. is constant throughout the trial, then, if a line of coal consumption be plotted of which the "abscissa" is the total time and the "ordinate" the total coal used, the line should be a straight line; but if any error has been made in counting the number or weight of the buckets it would show itself by an alteration of slope of the straight line. That method has been used by the Committee of Mechanical Engineers, and was found useful by them. The author gives the result of a special trial in which the consumption of coal per H. P. was measured at different percentages of full power. Professor Unwin, in a lecture to the Society of Arts, in January, gave curves showing that if the H. P. was decreased by decreasing speed or boiler pressure, the consumption per H. P. was increased at the reduced power; but if, on the other hand, the power was reduced by increasing the expansion the consumption per H. P. decreased. These results of the author's seem to fall under the latter head, and this result of Professor Unwin's would support the view taken by the author that the power should be reduced by increasing the expansion. It sho ld be noted that the expansion should not be so great that the pressure at release in the low pressure cylinder is less than the sum of the back pressure together with the friction pressure. The expansion

should not be carried on so far that the pressure at release in the low pressure cylinder falls below about 6 lbs., as Mr. Williams gives it, otherwise there will be a loss from excessive expansion. Then, with regard to the steam jacket, the committee appointed by the mechanical engineers recommended that the jacket should be so adjusted that the steam at release in the cylinder should be dry. This will agree with the author's condition that there should be some moisture on the sides during the stroke, since the release will not occur till about 0.8 to 0.95 of the stroke, and up to that point the steam will have contained a certain diminishing amount of moisture.

H. S. H. Prince Louis of Battenberg: I should like to make a few remarks from the point of view of captain of a ship, and to deal *seriatim* with a few of the hints which were thrown out, more especially as regards effecting economy in coal by restricting the expenditure for auxiliary purposes. I thought the matter over a great deal when I was in command of one of those small ships full of engines, and I came to the conclusion that really the only point in which you could possibly effect economy was electric lighting. Steering by hand is no doubt another point, but it should not be forgotten what, to my mind at least, is the chief advantage of steering by steam, viz.: the rapidity with which you can put the helm over to avoid danger. Under certain conditions, no doubt, you could steer equally well by hand, but if you get anywhere within frequented waters, working in a squadron or anything of the sort, I do not see how you could possibly do it. That and electric lighting are the only two items of expenditure which are pretty well permanent and constantly recurring, because, after all, the pumping machinery for torpedoes, weighing, stowing anchors, and so on, are intermittent. As Admiral Colomb said, as regards weighing the anchor, no doubt you would have plenty of "beef" to do it without machinery, but then the question of time comes in. After all, I take it, you could do a great many things by hand in a ship: if you have unlimited time you have usually plenty of men to do it. In the Dreadnought, we could load and trim our turrets by hand; it would take us about half an hour as against five minutes by machinery, and the same argument, I take it, applies wherever you use steam. With regard to the question Admiral Colomb raised about using one screw with the wind on the bow, I tried it and I found it certainly was so. It was the only point where we could use one screw, I would not say with advantage, but where it appeared to me to be really possible to use it. After all, the captain of a ship is rather hampered in giving effect to economies in coal consumption, on the lines thrown out by Mr. White, for instance. As he rightly said, in the squadron you must have an excess of speed for tactical purposes and even for ordinary station-keeping purposes. But, in these days, the moment you are away from the flag there are two conditions; either you are told to go to a certain place at a certain speed, or else you are told to cruise within

certain waters at your discretion. Your other instructions tell you that when you are cruising you are to use what is called "ordinary speed" according to the scale laid down, provided it is not faster than the most economical speed ; so that in either case you are practically tied down by instructions, apart from the expediency of using your most economical speed. I should like to revert again, for a moment, to the question of electric lighting. In the Scout, for example, we were peculiarly situated. We were the only ship in the service then fitted with accumulator batteries. I was very much in favor of them after we found out how to work them. My engineers, however, were not very fond of them, as it gave them a great deal of extra trouble. I have never been able to clearly satisfy myself that it was more economical to use them as far as the coal consumption went. Practically it meant a great deal more. In the Mediterranean summer cruise, where you frequently anchored for five or six days, she was the only ship in the squadron which put the whole of her fires out on anchoring, and it affected us more because we had no auxiliary boiler. Now, besides being able to keep the boilers cleaner it reduced the temperature of the whole ship, and conduced to comfort and cleanliness generally. Lighting by accumulators could only be done by strictly economizing lights ; we made rigid rules as to the use of incandescent lights, which worked very successfully.* As regards internal lighting generally, it has always struck me that nowadays, where formerly you burnt a purser's dip, you are not satisfied unless you have a 50-candle power light. Surely there must be some medium between the two. It is all very well turning night into day, but you would nowadays turn night into more than day itself ever can be. My impression is that the incandescent lights are somewhat recklessly used on board ship. It reduces their life and means, of course, increased expenditure of coal. That is a point on which, I am sure, by strict attention and going carefully into it, coal can be economized very largely.† The figures which Mr. Riley gives are quite extraordinary, as showing the difference in the radius and distance with and without the electric light, and they are well worthy of consideration.

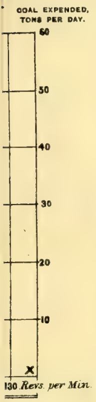
ADMIRAL CHURCH : My opinion most entirely coincides with what has fallen from Prince Louis of Battenberg about the economy made in the auxiliary engines. There is no doubt that these engines are put into the ships to make them more efficient for the war purposes for which they are

* I am afraid I strayed rather away from the point under discussion by mentioning accumulators. Their value has no doubt been decreased by the more general introduction of auxiliary boilers.—L. B.

† I meant to have added that I do not advocate any restriction in coal expenditure for internal lighting, fresh water for cleaning purposes, generally, etc., in times of peace. Coal is always to be had, and its generous use for the purposes enumerated undoubtedly adds vastly to the general well-being on board ship.—L. B.

built, and if too much economy is observed in peace-time we should not be well up to working those very engines which we should have to use in war-time. I think it is absolutely necessary to use these engines in peace-time as we shall have to do in war. There is no doubt that in war-time the electric lighting of cabins and of the mess-rooms will be dispensed with, but I do not see, myself, what other economy in that respect we could carry out.

ILLUSTRATE MR.



KS.

FIG. 1. _ DIAGRAM SHOWING MOST ECONOMICAL SPEED.

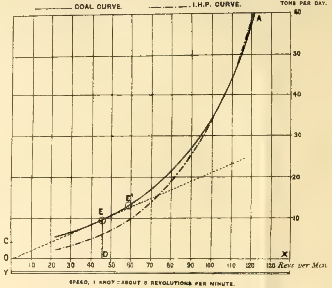


FIG. 2. INDICATOR DIAGRAMS.

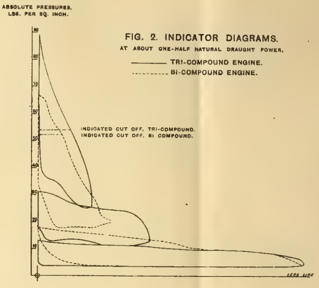


FIG. 4. TO ILLUSTRATE MR. WINGFIELDS REMARKS.

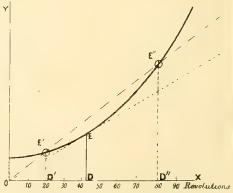
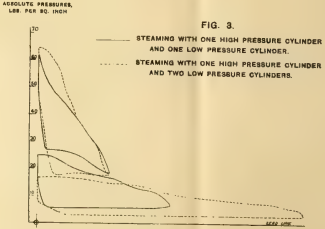


FIG. 3.



U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

PIGEONS FOR SEA SERVICE.

By Assistant Professor H. Marion, U. S. Naval Academy.

With an account of their use during the practice cruise of the Constellation of 1893.

II.

The practice cruise of the U. S. P. S. Constellation of 1893 afforded another opportunity for using homing pigeons as messengers. The experiment proved entirely successful, and the practical value of this service for naval purposes was again fully demonstrated, as it had been on the two previous cruises of the Constellation (see Proceedings of the U. S. Naval Institute, Nos. 54 and 64). The report made on this subject by Commander C. M. Chester, U. S. N., from the memorandum prepared by Ensign F. K. Hill, U. S. N., who had charge of the matter during the practice cruise of 1893, states as follows: "Twenty-seven pigeons of various ages, and trained up to corresponding lengths of flight (from 20 to 150 miles) were furnished the Constellation from the Naval Academy loft when she left Annapolis, the 5th June, 1893. The first necessity for sending pigeons occurred about 12 miles from Annapolis, when Thomas Gilkie, seaman, was killed and it was necessary to send the body ashore. As speedy delivery was desired, duplicate messages were sent by two 150-mile birds, telling of the accident, and that the body would be sent ashore in the ship's steam launch. Later, the weather proving unfavorable, two more 150-mile birds were sent with a message, asking that the Standish be sent for the body.

"This message was sent at 9.30 A. M., June 7. The Standish was alongside a little after noon of the same day, and brought back the four birds which had carried the messages.

"With these two exceptions, birds were liberated during the cruise down the bay, at distances corresponding to their ages and training.

"The last birds flown were the four 150-mile birds brought back to the ship by the Standish. They were liberated June 12, at 10 A. M. Lat. 36°50″ N., Long. 75°10″ W., and arrived at Annapolis early the following morning.

"One bird carried a message to Captain Phythian changing the objective point of the cruise from Lisbon to Funchal, and requesting that mail be sent to the latter place.

"Of the twenty-seven birds liberated, but two failed to reach Annapolis. Twenty-four messages were taken from birds on their arrival, and one was afterwards found in a nest in the cote. As one of the two messages which failed to reach Annapolis was a duplicate, but one message was really lost."

Commander Chester states that the result of this work, as shown in Mr. Hill's memorandum, was very satisfactory, and says in conclusion: "I believe the adaptability of homing pigeons for naval purposes has now passed beyond the experimental stage, and, if the government desires to perfect this system of communication, it would seem appropriate that the necessary expense of maintaining the same should not be left to depend upon the subscriptions of individuals, as heretofore. In my opinion, the subject is worthy of generous consideration."

Another experiment on a larger scale took place during the recent naval rendezvous in Hampton Roads, when pigeons were liberated from the Dolphin and the Atlanta, carrying important messages from the Secretary of the Navy and others to Annapolis, Washington, Richmond, Philadelphia and other cities, over distances ranging from 50 to 300 miles.

The Annapolis birds of the Naval Academy loft liberated from the Dolphin, which had been previously trained, returned *all* in very good time and the messages forwarded were received on the day of liberation.

The only failures, which were few, were caused by *untrained* birds, furnished from other places, or by the *defective* manner of fastening the message to the bird. They emphasize the necessity of *previous* training and the importance of a systematic organization.

Homing pigeons were also successfully used as message bearers during the recent trial trip of the U. S. S New York.

Besides the original cote, No. 1, formerly of the U. S. P. S. Constellation, and now in the Naval Academy loft, there are three cotes on board U. S. vessels of war; namely, No. 2, on board the U. S. armored cruiser New York, now in the harbor of Rio, Brazil (which was donated by the late Geo. W. Childs, and is complete in all its parts), No. 3, on board the U. S. S. Bancroft, now at the Naval Academy, Annapolis, and No. 4, on board the U. S. S. Monocacy, at present in the Yang-Tse River, China. This last has been recently established by Lieutenant A. L. Hall, on the model of the Constellation's cote.

All the principal European powers have now a well organized messenger pigeon service for both military and naval purposes, in most cases under the direct control of the government. Canada has been of late very active in establishing new messenger pigeon stations along the Atlantic coast, and efforts are now being made * to connect Sable Island with Halifax by pigeon post (a distance of about 150 miles) with a view to signal shipwrecks in the vicinity of the island and receive rapid communications from vessels cruising between these stations.

Recent experiments abroad, as well as in the United States have demonstrated the fact that *well trained* birds can be relied upon to carry messages from ships to shore when *no other means* of rapid communication are available and will result, it is hoped, in the establishment of a naval messenger pigeon service in the United States (as advocated in No. 64 of the PROCEEDINGS) similar to those existing in the European navies.

* Since sending the above to press the writer has received a communication from the Minister of Marine and Fisheries of Canada, stating that a report has been received from Captain Dopping Hepenstal, R. E., Supt. of Signals at Halifax citadel, informing the Department that the proposed line of communication by pigeon post between Sable Island and Halifax (distance about 150 miles) has been successfully established.

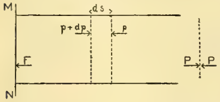
U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

VELOCITY OF COMBUSTION OF AN EXPLOSIVE UNDER VARIABLE PRESSURE.

By Lieutenant J. H. Glennon, U. S. N.

[*From Interior Ballistics.*]

Let MN (see Figure) represent the burning surface of a powder grain (smokeless or otherwise). From this, as shown in the figure, issues a stream of powder-gas normally. Denote the pressure of the powder-gas at the instant of formation by F, and the pressure of the gaseous surrounding medium, outside the issuing streams of gas by P. Also place p equal to the varying pressure in the stream, and ρ equal to the variable mass of unit volume, in it. Suppose the cross-section of the stream to be unity, and assume anywhere in it a lamina of thickness ds and at right angles to it. The measure of dp, the accelerating force of the lamina, will be (mass $\times$ acceleration)



$$dp = \frac{dV}{dt}\rho ds = \frac{VdV}{ds}\rho ds = \rho V dV.$$

The transformation being adiabatic,

$$p = k\rho^n \text{ and } \rho = \frac{1}{k_1}p^{\frac{1}{n}};$$

$$\therefore VdV = k_1 p^{-\frac{1}{n}} dp.$$

The initial velocity of the issuing gas is 0, and we will denote the final velocity by V_1.

Integrating between proper limits, combining constants in one when possible, and remembering that the velocity increases as the pressure decreases,

$$\int_0^{V_1} V dV = k_1 \int_P^F p^{-\frac{1}{n}} dp, \text{ or } V_1^2 = k_2\left(F^{\frac{n-1}{n}} - P^{\frac{n-1}{n}}\right);$$

$$\therefore\ V_1 = k_2^{\frac{1}{2}}\left(F^{\frac{n-1}{n}} - P^{\frac{n-1}{n}}\right)^{\frac{1}{2}}.$$

This is the velocity with which the gas passes a point in the stream where the pressure is P. The mass of unit volume of the gas at the same time will be determined by

$$\rho_1 = \frac{P^{\frac{1}{n}}}{k_1}.$$

and the mass of gas that flows past the above point in unit of time will be

$$\rho_1 V_1 = K_1 P^{\frac{1}{n}}\left(F^{\frac{n-1}{n}} - P^{\frac{n-1}{n}}\right)^{\frac{1}{2}}.$$

But if the density of the powder grain is constant the mass of gas formed, which will be the same as that which passes any point, will be proportional to the velocity of combustion. We may, therefore, write for the velocity of combustion,

$$V' = KP^{\frac{1}{n}}\left(F^{\frac{n-1}{n}} - P^{\frac{n-1}{n}}\right)^{\frac{1}{2}}. \quad . \quad . \quad . \quad . \quad (1)$$

If F could be increased the velocity of combustion might be increased indefinitely. If P is constant, we know that V' is; therefore F is constant. The surface of the powder grain next the heated gas is evidently in a state of unstable equilibrium, held in check by the pressure, and if the pressure on the surface is too great, it will remain in that state. As the pressure is lessened by expansion of the gas, the reaction already begun on the surface is completed and gas is again produced, raising the pressure till again too great, stopping the reaction as before, and so on.

In order to keep the mass of gas flowing past a fixed point in the stream constant, the density of the power being variable, the "velocity of combustion must vary inversely as the density." This law was first enunciated, as the result of experiment, by General Piobert.

If P is very small as compared with F, we may assume the quantity in parentheses in (1) as constant (dropping the last term) and write

$$V = k'P^{\frac{1}{n}},$$

or, substituting for n its value 1.4,

$$V = k'P^{.7}.$$

This agrees with the experiments of M. de Saint Robert. He filled a lead tube with gunpowder, drawing the tube out and cutting it into equal lengths. These lengths were burned at different altitudes above the sea. From these experiments, M. de Saint Robert concluded that the velocity of combustion of gunpowder varied as the ⅔ power of the pressure of the surrounding medium. Captain Castan verified the increase of velocity of combustion with pressure by means of a tube containing powder and having a hole for escape of the gas. By changing the size of the hole he changed the pressure.

As P begins to be appreciable comparatively with F, the quantity in parentheses may be represented approximately by the product of a constant and a small negative power of P. This power increasing (negatively) is still quite small for the pressures employed in guns. As a sufficient approximation we may, therefore, employ a principle which is undoubtedly the result of the closest observation, that of M. Sarrau, namely: The velocity of combustion of gunpowder (in guns) varies as the square root of the pressure of the surrounding medium. That is,

$$V = kP^{\frac{1}{2}}. \qquad (2)$$

It may be noted in the deduction of (1) that no account is taken of the non-gaseous residue of gunpowder. The close agreement of the formula with M. de Saint Robert's experiments, however, seems to indicate that the consideration of the residue would effect a needless complication of the subject. Moreover, this consideration would be impossible unless the residue were supposed formed in its entirety at the instant of combustion, and there is no real reason to suppose that it is not a result of expansion.

For smokeless powder, and for other explosives leaving no residue, in process of combustion as distinguished from detonation, the above equations should hold with exactness.

U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

SEA POWER.

No apology seems necessary for transferring to our pages from the columns of the *London Times* and *Fortnighlly Review* the following articles, the first two suggested by the anniversary of the battle of Trafalgar. The first, a letter from "A Student of Naval History," points to two lessons to be drawn from that battle; "his (Nelson's) legacy to us," he observes, "is, that strategic and tactical study is that with which, above all things, a naval officer should occupy himself." The other lesson is that "the sea-trained fleet, weaker in numbers as it was, not only defeated, but crushed the harbor-trained fleet."

The second article is an editorial of the *Times*, in which the writings of an officer of our own navy, Captain A. T. Mahan, are alluded to in such high terms of commendation, that we take equal pleasure and pride in reproducing them for the benefit of those of our readers to whom the English papers may not be accessible.

The editorial, it will be observed, was called forth by the letter already referred to. After alluding to "Sea Power," as "having effected a revolution in the study of naval history," it goes on to say that "it is not difficult to trace the influence of this writer's teachings in the letter of "A Student of Naval History." If imitation be the highest form of flattery to a member of the profession, we have here a compound compliment well worthy of permanent record in these pages.

The success that has attended Captain Mahan's labors as a lecturer on naval history, suggests the thought that there may be, and probably are, other naval officers who would achieve a like success in other branches of professional research if the way were only opened to them.—Editor.

THE ANNIVERSARY OF TRAFALGAR.

[*London Times*, *Oct.* 21, 1893.]

To-morrow (Saturday, October 21) will be the anniversary of Trafalgar. The reflections to which the recurrence of the day gives rise may lead us to consider the lessons which that great victory teaches. The intensely dramatic nature of the combat so dazzles us that it is not always easy to distinguish its real significance. The shattering in less than two hours—between 12.20 p. m. and 2 p. m., in which interval the action was practically decided—of the great fabric of belligerent policy which Napoleon had for years been laboriously trying to construct is by itself at most enough to monopolize our whole power of attention. The catastrophe was as awful as any that the tragedians of antiquity ascribed to the intervention of the gods. The tremendous interest of the tragedy is immensely augmented by its inseparable connection with the death of the most romantic personage in modern history. To our fathers of 1805 the result of Trafalgar seemed only the frustration—for a long time if not for ever—of Napoleon's long-cherished project of invading England. We who live now can see that the consequences were of far wider reach. We know that the victory of October 21 permitted the development of the British Empire as it is at this minute; that it put the extension of British rule in India above the power of any European rival to hinder it; that it secured the maintenance of that rule; that it rendered possible the eventual rise of great English communities in southern seas; and that it was the parent of a vast expansion of our ocean commerce. All this may be of mere historical interest; but Trafalgar teaches us at least two lessons which are worth learning at the present day.

The beaten fleet was larger; its ships, compared with those of corresponding class, were bigger; its guns were heavier; its weapons generally were superior; its crews were numerically stronger than the British. It had just left port, where it had lain for many weeks in the neighborhood of a great naval arsenal. Though every want may not have been supplied and every defect may not have been made good, the French and Spanish ships had had at their disposal equipment resources far exceeding in abundance those to which Nelson's were restricted. That there was no inferiority in courage on the part of our antagonists was proved by

many incidents. To take a single one, the devoted gallantry of Captain Lucas and the crew of the Redoutable, which did not surrender till five-sixths of her officers and men had been killed and wounded, has never been surpassed in any navy. Why was it, then, that we were able to inflict upon our enemy so crushing a defeat? In the answer to this question are contained the two lessons which the battle teaches.

The British Admiral was an industrious student of strategy and tactics.

If there was ever an officer to whom the study of these subjects might seem unnecessary, assuredly it was Nelson. Never in any commander have the strategic faculty and the tactical faculty—by no means necessarily compatible—been so conspiciously united as they were in him. His extraordinary tactical gift had been displayed at St. Vincent. His equally extraordinary strategical gift had been displayed in the Baltic when he discerned the main objective and urged his chief to strike at it first and leave the secondary to be dealt with afterwards. It was made still more clearly apparent in his favorite maxim that the British fleet should always try to keep touch of and as close as it could to the fleet of the enemy. Gifted as he was, he still made strategy and tactics his study. To the closeness of this study was owing in no small degree the remarkable lucidity of his written explanations of his method of fighting. Speaking of the celebrated memorandum of October 9, Professor Laughton says, "No clearer exposition of tactical principles was ever penned." On questions of mere *matériel* Nelson, like all great commanders, thought little. The enormous dimensions of the Santissima Trinidad, the comparatively great weight of the enemy's shot, had for him far less importance than the enemy's strategy, tactical formations, intentions, and mode of engaging. His genius told him that to beat a powerful enemy you must understand the strategic requirements of the campaign and the tactical requirements of the battle. His legacy to us is, that strategic and tactical study is that with which, above all things, a navy officer should occupy himself.

The other lesson to be learned from Trafalgar is this—the weaker sea-trained fleet beat the more powerful harbor-trained fleet.

The French and Spanish navies of 1805 were almost as strictly

harbor-trained forces as any navy of the present day. This was not voluntary on their part. The activity of our fleet enforced it on them. A frequent occupation of the watching British ships was to stand close in and look on at the harbor exercises sedulously carried out in the waters of Brest and Toulon. The time that the officers of our enemy's fleet could not devote to gaining sea experience was devoted to scholastic study and many non-naval exercises. In one or other of these some attained a high degree of proficiency. There were probably as many trained mathematicians in one of Villeneuve's ships as there were in the whole of Nelson's fleet. Whilst dozens of officers in the former could have named the supposed curve followed by a cannon-ball in its flight, in the British fleet there was probably not one—unless it were a chaplain—who had ever heard of the appellation. In barrack-square drill and in mimicry of the less useful evolutions of infantry soldiers the enemy's seamen were, no doubt, immeasurably superior to those who fought under Nelson's flag. The sight of young officers struggling for "marks" in class-rooms, as though they were scholars of a provincial grammar school or training college, was familiar enough in Continental ports. Familiar, too, was the imposition on naval officers of a scholastic course imparting a faint and to-be-speedily forgotten smattering of mathematics, and a fainter smattering of natural science, suitable for those who aspire to posts of ushers in schools of the less efficient class. Fortunately for England, it was not on her own but on the enemy's officers that this course was imposed. This, then, is the second of the two lessons of Trafalgar—the sea-trained fleet, weak in numbers as it was, not only defeated but crushed the harbor-trained fleet.

Your obedient servant,

A Student of Naval History.

October 20.

[*London Times*, *Oct.* 23, 1893.]

Saturday, as we were opportunely reminded by "A Student of Naval History" was the anniversary of Trafalgar, undoubtedly the greatest naval victory of our history; perhaps, in its wider issues and effects, the most decisive battle of the modern world. Our correspondent writes with great authority and insight, and there are not a few reasons, some of which will occur to all at the

present moment, why the lessons which he inculcates in so salutary and so timely a fashion should be pressed upon the earnest attention of his countrymen. Englishmen are very apt to ignore, or, if not to ignore, to misapprehend, the real teaching of their naval history. Historians have rarely seized its true import and significance. They have treated it, for the most part, as a series of external episodes, subsidiary and subordinate to contemporary military enterprises, and not as the central and dominant factor of our National and Imperial fortunes. It has been reserved for an American writer to show us, almost for the first time, what "Sea Power" really is, and what its influence has been on the history and condition of the modern world. By his pregnant conception of "Sea Power" and his masterly exposition of its influence upon history, especially upon the history of the British Isles, Captain Mahan may almost be said to have effected a revolution in the study of naval history similar in kind to that effected by Copernicus in the domain of astronomy. It is not difficult to trace the influence of this writer's teaching in the letter of "A Student of Naval History." "At Trafalgar," writes Captain Mahan, "it was not Villeneuve that failed, but Napoleon that was vanquished; not Nelson that won, but England that was saved." . . . "The tactics at Trafalgar, while open to criticism in detail, were, in their main features, conformable to the principles of war, and their audacity was justified as well by the urgency of the case as by the results; but the great lessons of efficiency in preparation, of activity and energy in execution, and of thought and insight on the part of the English leader during the previous months are strategic lessons, and as such they still remain good."

It is virtually on this text that "A Student of Naval History" takes up his parable. Trafalgar was fought and won by a fleet inferior to the enemy in numbers and in armament, and by tactics open to criticism, not merely because Nelson was the greatest naval leader the world has ever seen, but because he devoted all the powers of his unique genius to the patient study of the naval problem before him, and to the consummate adaptation of naval means to naval ends. It was not the intuition of genius alone, but incessant and profound study, directed, no doubt, and inspired by genius, that enabled him to penetrate to the core of a problem and to disengage its essence from its accidents. This it was that

riveted his attention on Villeneuve's fleet as the one strategic object, paramount to all others, in his front, that carried him to the West Indies in pursuit of it, and brought him back into European waters in time to frustrate the combinations of Napoleon. This it was, too, that determined the tactics at Trafalgar—tactics theoretically faulty in some respects, but justified in his hands, as Captain Mahan says, "as well by the urgency of the case as by the results." This, according to our "Student," is the first great lesson of Trafalgar—the lesson that even the most consummate naval genius cannot dispense with—patient and prolonged study of the "strategic requirements of the campaign and the tactical requirements of the battle." The second lesson is that the sea-trained fleet, although inferior, defeated and crushed the harbor-trained fleet, superior as it was in number and size of ships, in armament and weight of metal, and in the numbers of men engaged. Here, again, we may cite the impartial authority of Captain Mahan. The French officers were highly trained in all but the one thing that makes the seaman—namely, constant experience and exercise at sea. This was the training that Nelson's officers got, and they got very little else. Nevertheless, Captain Mahan attributes the victory of Trafalgar quite as much to "the very superior character of the British *personnel*" as to the superior strategic position occupied by the British fleets. "Continually cruising, not singly, but in squadrons more or less numerous, the ships were ever on the drill ground—nay, on the battlefield—experiencing all the varying phases impressed upon it by the changes of the ocean. Thus practiced and hardened into perfect machines, though inferior in numbers, they were continually superior in force and 'mobility to their opponents.'" This is the true training of the naval officer. He cannot be made a seaman without constant experience of the sea. Everything else that he learns in the course of his professional studies is, or should be, merely subsidiary and subordinate to the teaching of the sea itself. His proper training-ground is the quarter-deck and the bridge of a sea-going ship at sea. It is not the mastery of scientific appliances nor the chamber and lecture-room study of the sciences on which they depend, important though these things undoubtedly are, that makes a man a seaman of the type of Nelson and his officers. The sea itself is the one element of a seaman's experience that cannot be reduced to book-

knowledge and must be assimilated on the quarter-deck. A man is no more made a seaman by scientific study on shore than he is made an athlete by a knowledge of human physiology or of the chemical properties of food.

If, then, we would profit by the true lessons of Trafalgar, we must never allow ourselves to forget that, while the genius of Nelson was inspired and sustained by profound study of the art and history of naval warfare, the training of his officers was acquired on the sea and from the sea. Their enemies were as brave as they were, and in theoretical training they were far superior to them. They had learned all that a seaman could learn on shore and in harbor, but, when they came to apply at sea what they had learned only on shore, their enforced lack of sea experience told fatally against them. We are in some danger of suffering from a like disability in the naval warfare of the future. Whether our admirals are students of naval strategy in the sense that Nelson was it might, perhaps, be invidious to inquire; but it is certain that our officers are now encouraged, and practically required, to pursue scientific training on shore at the cost of experience at sea. We live in a scientific age, of course, and a modern battleship is a wilderness of scientific appliances. A naval officer should be master of all the knowledge that enables him to fight his ship to the best advantage, or, if he is in command of a fleet, to divine and frustrate the strategic designs of his adversary. But, of this indispensable knowledge, surely the most important factors are those which are derived, on the one hand, from an intelligent study of the principles of naval warfare as illustrated by its history, and, on the other hand, from the teaching of the sea itself. Our forefathers acted on these principles, and Trafalgar was the glorious result. We cannot always have Nelsons at command, but we may, and must, at least take care that, in making our officers mathematicians and electricians, engineers and artillerists trained for the most part on shore or in harbor, we do not deprive them of those qualities and that experience which enabled the sea-trained fleet of Nelson to annihilate the superior harbor-trained fleet of his ill-starred opponent.

SEA POWER: ITS PAST AND ITS FUTURE.*

[*Fortnightly Review.*]

The continents and islands of the world are growing tame and vulgarized. Already at the bidding of the old civilization they have surrendered very nearly all their secrets and mysteries, and many of their idiosyncrasies. He who will may now go by train to Jerusalem or Samarkand. In Japan they brew excellent bottled beer and manufacture matches that strike only on the box. Both are exported to India. A telegraph wire is being laid almost through the village in which Livingstone died; the Sandwich Islands have experienced a *coup d'état* of the most enlightened and least bloody European type; Niukalofa, the capital of the Tonga-Tabu Islands, has a daily postal delivery; Delhi enjoys a telephone system; China buys her field-guns at Essen; the faithful Moslem from the farthest east makes the greater part of his pilgrimage to Mecca by steamboat; and the bicycle has crossed Asia.

Nor are there in these continents and islands many corners which European and American diplomacy can still regard as no-man's land. Progress has occupied, as well as overcome, almost every one of them, and we are rapidly nearing the moment when an attempt on the part of any government to make the smallest further annexation will excite throughout civilization a commotion scarcely less dangerous than would be excited to-day by a French occupation of Antwerp or an Italian seizure of Nice. The various continents and islands are, in fact, quickly settling down into order, and the discoverers, the adventurers, and the chartered companies will soon find no more savage worlds to conquer on shore. But the sea remains.

Twenty years, or a little more, may perhaps elapse ere the last scrap of Africa and the last Pacific islet shall be snatched from their aboriginal owners and formally added to the possessions of an older power. Thenceforward those who hunger for empire will be stinted of their ordinary food. No doubt they will continue to be as hungry as of yore, but they will have to starve, unless they either satisfy themselves with the accustomed pabulum at the risk

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of provoking a great war, or find some other and still plentiful diet which, in default of land, will content their appetites.

For thousands of years the struggle has been for earth. When the ownership of the whole of the earth shall have been determined, will there not arise an equally keen and persistent rivalry for the mastery of the sea?

I venture to think that there will, firstly, because humanity will continue to be acquisitive; and, secondly, because we are already beginning to learn that the empire of the ocean, or of particular parts of it, may be, from the military and commercial points of view, no less desirable than the empire of the solid land.

Some vague suspicion of the value of the ocean to him who might be wise and strong enough to take advantage of it may perhaps have flitted through the brains of those rulers of England who from early times exacted in the narrow seas the Honor of the Flag. But they obliged Frenchmen, Netherlanders, and Spaniards to strike their topsails, not so much because there was any clear and definite impression abroad that the dominion of the sea was a strategical and commercial benefit, as because the British race, in those days especially, despised foreigners and loved nothing better than to humiliate them, and because the Howards, the Drakes, the Blakes, the Monks, and the Ruperts were truculent dogs who found pleasure in flying at all who approached them. It was a question rather of national pride than of studied policy. And so little was the claim to the Honor of the Flag regarded as being of serious importance, that in the very days when England was strongest on the sea and could most easily enforce it, she began gradually to cease to press it.

In the last century, and during the whole period of the Revolutionary and Napoleonic Wars, every Englishman recognized, in a general way, that a great and efficient navy was necessary, indirectly for the protection of his shores, and directly for the winning of battles, the destruction of the enemy's commerce, and the accumulation of prize-money; but no one in Europe seems to have then clearly realized all that preponderating naval power may mean to its possessor if it be intelligently employed. No one accepted it at its true and full strategical value. No one pointed out the significance of the Nile and of Trafalgar. It was enough to regard those actions merely as glorious victories in which so

many Frenchmen were killed or wounded and so many French line-of-battleships destroyed or taken. British naval strategy, although upon the whole it was soundly guided, and although under Hawke, Rodney, Hughes, St. Vincent, and Nelson it was conducted almost flawlessly, was not professedly based upon scientific principles. Much of it was of the happy-go-lucky order. It succeeded because the execution of it happened to fall into the hands of geniuses, who worked not so much by the light of reason as by the light of inspiration. The naval tactics of the age were of the same type. The manœuvre of breaking and cutting off a part of the hostile line gave Great Britain more than one glorious victory; yet it seems to have been first adopted upon the spur of the moment, and to have been afterwards utilized again and again in response to the promptings, not of logical deductions but of practical experience. That John Clerk, of Eldin, had advocated it from the arm-chair before it was employed in the Battle of the Saints is a coincidence only. It had been employed, and with success, before Clerk was born. And as for the particular manœuvre of the 12th of April, 1782, it was the result of no deliberate intention but of a shift of wind. There were such things as strategical and tactical axioms, but they were crude and general. Victories were valued chiefly for their immediate and most tangible results. Their probable bearing upon the issue even of the naval campaign was not seriously studied. Their possible bearing upon the issue of the campaign which was concurrently in progress on shore was often altogether ignored.

It was from this standpoint, and from no higher one, that in 1822 William James, one of the most pertinacious of investigators and most plodding of dullards, published the best and worst of all naval histories in the English language—that of the eventful period between 1793 and 1815. All earlier English naval histories leave very much to be desired not only as regards the arrangement of events and the attribution of them to their true origins and to those phases of change to which they conduced, but also as regards the accuracy of the facts set forth. Lediard is little better than Burchett. Schomberg is a great deal worse than Campbell. James set a new example. Except, perhaps, in the case of some of the incidents of the war of 1812, he honestly did his utmost to satisfy himself of the absolute truth of every statement which he submitted

to his readers. He wrote hundreds of letters to the surviving actors in the events which he purposed to describe. He read and digested all the dispatches, logs, gazettes, previous histories, foreign reports and private narratives upon which he could lay his hands. He carefully balanced conflicting accounts, and arrived, in the majority of instances, at conclusions the correctness of which has never yet been successfully attacked. He went to immense pains to give the exact Christian names of all officers whom he had occasion to mention, and to analyze the true force of every ship the exploits of which he recounted. Never was there a man more painstaking, more indefatigable, more scrupulously conscientious—save, as I have said, when he was in presence of the Stars and Stripes. Yet, though he presented to the world a monument of his industrious patience, he failed utterly to give it a naval history in the proper sense of those words. His history is nothing more than a long string of disconnected episodes, a series of miscellaneous dioramic views, each very well done, and each accompanied by an explanatory commentary, but each entirely dissociated from the view which precedes and from the view which follows it. After reading Mr. James' numerous volumes the student is tempted to the conclusion that in the days of the Republic and the First Empire the nations embarked upon naval enterprises as thoughtlessly as young English couples embark upon matrimony, and with as little eye to the serious and legitimate objects of the undertaking. He can distinguish very few traces of the existence of steady policy or of intelligent and provident plans of campaign. He learns that at a given moment a fleet of a given force was in a given latitude; but he is left to discover for himself how it got there and why it went there. James' usual preface to an account of a hostile meeting between single ships runs to the effect that, "On the 13th of March, in latitude 50° 22′ north and longitude 18° 14′ west, the British 12-pounder 32-gun frigate Pantomime, Captain Nelson Rodney Howe, being on a cruise, descried the French 36-gun frigate Chocolat," etc., etc. He gives no hint of the general policy in pursuance of which frigates were cruising in those waters, and his omission to afford information upon this subject intensifies the reader's suspicion that, to a large extent, in those days ships were sent hither and thither at hazard, that there was no proper directing brain at home, that the strategical factor was often absolutely

neglected, and that actions were won entirely by the adventitious and unaccountable presence of a superior force at the right point, by simple hard fighting, or by the heaven-born genius of the senior officer who by chance was upon the spot.

Yet for more than half a century James was everywhere accepted as a great naval historian; nor did English-speaking students ask or hope for a greater one. The truth is that James was a remarkable collector of facts, a brilliant diarist. Of the real historian's breadth of view he had no share whatever. He knew not how to separate the important from the trivial. He was incapable of looking behind or to either side of the events which he was describing. He had no sense of the continuity of episodes. He expressly declares: "In reasoning upon the issue of any battle, I have found neither the talent nor the inclination to dwell on the consequences which might or did accrue to either nation from success or failure. The merits of the combat, considered as a combat, I have fully detailed and freely discussed, and have left the field of politics open to those who know better how to traverse it." To say that James avoided the field of strategy with almost as much pains as he avoided the field of politics is to commit no exaggeration; and to pretend that naval history can be seriously discussed without reference both to politics and to strategy is obviously absurd. It is, therefore, surprising that during the fifty years which followed the publication of James' work, no English writer made an effort to examine into the causes, the origins, the ruling principles, and the results of the series of events which James had so carefully but so inconsequently described.

At last there arose, in Great Britain, Philip Howard Colomb, and, in America, A. T. Mahan. The former, an Irish naval officer, retired from the service in 1886 and consoled in the following year with the rank of rear-admiral, and in 1892 with that of vice-admiral, was, at the period of his active life, a distinguished ornament of his profession. His book, "Naval Warfare; its Ruling Principles and Practice Historically Treated (1891)," exhibits him as a very indifferent historian. He shows, it is true, that he comprehends the way in which the naval history of the past must be viewed ere it can provide useful lessons for the future; but he is without the literary art, and he presents neither his facts nor his conclusions in such a manner as to convince the reader. Verbose to a degree,

afflicted with an apparently incurable mania for dancing round every subject instead of at once attacking it, obscure in his processes of reasoning, and unable, in spite of the inherent attractiveness of his materials, to breathe life into them, Admiral Colomb has produced a book which is a little learned and perfectly unreadable. He has tried, and he has failed, to do what James left undone. Captain A. T. Mahan, U. S. N., who is likewise of Irish descent, engaged, at about the same time, on a task similar to that in which Admiral Colomb gained no laurels. The American officer, who is still on the active list of his navy, was fitted by nature as well as by training for the work to which he happily turned his hand. Possessed of a charming style; precise and clear instead of verbose; completely conscious of what he intends to convey and perfectly competent to convey it; and dowered with a perspicacious breadth of view which dwells on all that is important and passes over all that is irrelevant, Captain Mahan has given us two very remarkable books, "The Influence of Sea-Power upon History, 1660–1783" (1890), and "The Influence of Sea Power upon the French Revolution and Empire, 1793–1812" (1892), books which, it may with truth be asserted, have already firmly established themselves as the standard strategical histories of the periods with which they deal. Sea power, of course, has influenced the world in all ages. So also has oxygen. Yet, just as oxygen, but for Priestley, might have remained until this day an indefinite and undetected factor, so also might sea power but for Mahan. The predecessors of each discoverer were conscious that around them was something which was responsible for certain observed results, but the predecessors of neither knew exactly what that something was. Priestley explained, "The effects are produced by oxygen; here is oxygen, and you may obtain it after such and such a manner." Mahan announces, "The effects are due to sea power; here is a definition of sea power, and you may secure sea power after such and such a fashion." Not until a factor has been defined and separated can it be intelligently and fully utilized. Herein lies the merit of Mahan as of Priestley. The discovery of oxygen went far towards placing the science of chemistry on a sound basis. The discovery—for it is a genuine discovery—of the nature, limitations and influence of sea power does as much, and perhaps even more, for naval strategy.

Captain Mahan's discovery is now more than three years old, and during those three years it has been so widely written and spoken about in Europe, as well as in America, that its nature can scarcely remain unfamiliar to many. It will be here useful, nevertheless, to briefly summarize that portion of Captain Mahan's earlier book in which the elements of sea power are discussed.

The author bids us regard the sea as a wide plain, over which men may pass in all directions, but on which some well-worn paths show that controlling reasons have led people to choose certain lines of travel rather than others. We are to remember, too, that travel and traffic by sea have always been easier and cheaper than by land. The countries which border upon the sea may be looked upon in the light of so many mountainous tracts abutting upon the edges of, or isolated by, the wide plain aforesaid. It is obvious that he who dominates the plain, across which transport is so cheap and facile; who can at will bar a path or trade-route; and who at all times retains for himself the ability to move freely hither and thither upon every part of the plain, holds a position vastly superior to the position of any of his neighbors. If, moreover, this dominator of the level plain be also the possessor of a few of the abutting mountainous tracts, and of some of the isolated hills which rise from the plain, it is clear that he enjoys additional advantages, especially over those of his neighbors who, like himself, have scattered possessions. He can insure and keep open communication between his various farms. They cannot, save with his permission. It is not necessary that he shall have such absolute mastery of the plain as to render impossible occasional hasty forays upon it from hostile hills. Those forays will not materially affect the general result. All that is necessary is that he shall be always the real tenant of the plain, and that he shall be strong enough to make trespassers and poachers flee at the approach of him or of his servants. His hold upon the plain and its pathways will, if he be a wise man, tighten as the number and value of his farms and products increase; and as his hold tightens, so will his power and influence grow among his neighbors. As a foe he will be feared—as an ally he will be welcomed; and he will become the arbitrator and peace-keeper of the district.

Substituting the ocean for the plain, and the nations and islands

for the surrounding and isolated hills, we get a tolerably true picture of the general conditions which make sea power the paramount factor in the ultimate solution of the majority of international questions. We see also how trade and commerce beget sea power, and how important a bearing sea power may have upon land power. We moreover, if we still keep the analogy in mind, may distinguish at once the terms upon which alone sea power can be maintained. It may be local sea power, or it may be universal ocean power; but whether it be the one or whether it be the other, it cannot be enjoyed by more than one tenant at a time in any given district. Again, the tenancy may be precarious, feeble, and uninfluential, or it may be unchallengeable and all-dominating. And its nature is necessarily to a large extent controlled by the geographical position, physical conformation, extent, population, national character, government policy and commercial needs of the tenant state. It is useless here to enter into consideration of the modifying effects of any of these conditions. They must suggest themselves to all thoughtful men. The important point to which attention should be directed is the law that sea power, or mastery of any sea, in proportion as it is complete, confers upon its possessor an ultimately dominating position with regard to all the countries the coasts of which border that sea. This is the gist of Captain Mahan's discovery. In his volume on "The Influence of Sea Power upon History, 1660–1783," he tested what was at first only a theory, by applying it to the second Anglo-Dutch war, to the Franco-English war with the United Provinces, to the war of France against combined Europe, to the war of the League of Augsburg, to the wars of the Spanish and Polish successions, to the war of the Austrian succession, to the Seven Years' War, and to the war of the American Revolution. So consistently did the theory everywhere fit in with the course of events, that all doubt as to its correctness disappeared. It is now accepted as a strategical fact. That it was left for Captain Mahan to discover is astonishing, for, after perusing his books, the reader is tempted to marvel that a law apparently so obvious could have escaped the notice even of early historians. Yet late writers, like Arnold and Creasy, as well as early ones, have dealt with so remarkable an example of the influence of sea power upon history as is afforded by the final success of the Romans against Hannibal,

without perceiving that sea power had any definite bearing upon the result. As Captain Mahan says:

"The Roman control of the water forced Hannibal to that long, perilous march through Gaul in which more than half his veteran troops wasted away; it enabled the elder Scipio, while sending his army from the Rhone on to Spain to intercept Hannibal's communications, to return in person and face the invader at the Trebia. Throughout the war the legions passed by water, unmolested and unwearied, between Spain, which was Hannibal's base, and Italy; while the issue of the decisive battle of the Metaurus, hinging as it did upon the interior position of the Roman armies with reference to the forces of Hasdrubal and Hannibal, was ultimately due to the fact that the younger brother could not bring his succoring reinforcements by sea, but only by the land route through Gaul. Hence at the critical moment the two Carthaginian armies were separated by the length of Italy, and one was destroyed by the combined action of the Roman generals."

The fact that throughout the whole of his first great historical work Captain Mahan endeavored to exhibit the successive naval events of a period of a hundred and twenty-three years as illustrations of the truth of one general law of the higher strategy lends a singular consecutiveness and completeness to his admirably told narrative; and I am delighted that in his second great historical work he has adhered to the same plan. The period covered by the two volumes dealing with "The Influence of Sea Power upon the French Revolution and Empire" is nearly coincident with the period covered by James' "Naval History," and one cannot, as I have hinted, but compare the two books to the advantage of the newer one. The older one is, of course, far fuller in detail, but it is a book with no beginning, no plot and no *dénouement*, whereas Captain Mahan's work forms a harmonious whole.

The first volume begins with a survey of the course of events in Europe for the ten years preceding 1793, and with an account of the condition of the British and French navies at the time of the declaration of war by France. The influence of the Revolution upon the fleet of the Republic had not been of a healthy character. Many of the best officers had been proscribed, or had quitted the service in disgust; discipline had been subverted; and courage and audacity were believed by the chiefs of the Government to be almost the only qualifications needed by the fighting seaman. Immediately after the outbreak of hostilities, Admiral Morard de

Galles, one of the most capable of the remaining officers of the older and better school, wrote despairingly: "The tone of the seaman is wholly ruined. If it does not change we can expect nothing but reverses in action, even though we be superior in force. The boasted ardor attributed to them stands only in the words 'patriot,' 'patriotism,' which they are ever repeating, and in shouts of 'Vive la Nation!' 'Vive la République!' when they have been well flattered. They have no idea of doing right, or of attending to their duties." Mutiny, mismanagement, peculation and anarchy produced their inevitable results. The British Navy was in a better condition, but not by any means in a perfect one. Confusion and waste characterized the administration, and during the ten years' peace the efficiency of the service had noticeably slackened. "But," says Captain Mahan, "although administration lacked system, and agents were neglectful or dishonest, the Navy itself, though costing more than it should, remained vigorous; the possessor of actual, and yet more of reserved, strength in the genius and pursuits of the people—in a continuous tradition, which struck its roots far back in a great past—and, above all, in a body of officers, veterans of the last and some of yet earlier wars, still in the prime of life for the purposes of command, and steeped to the core in those professional habits and feelings which, when so found in the chief, transmit themselves quickly to the juniors." In the British as well as in the French fleets there was, it is true, some mutiny, but there was no anarchy. The forms of discipline were maintained, and though in more than one case the men refused to sail before their grievances were redressed, they qualified their refusal by adding, "Unless the enemy's fleet should put to sea." This spirit, the experience of the officers, and, last but not least, the material superiority of her fleet, placed Great Britain at an advantage from the hour when the first shot was fired. The relative forces, so far as ships of the line were concerned, was at that time: British, 115 vessels, 8718 guns, 88,957 pounds broadside weight of metal; French, 76 vessels, 6002 guns, 73,957 pounds broadside weight of metal. In 1793, therefore, France could not hope for success at sea. But although Great Britain entered the war allied with many of the nations of Europe against France, one by one her allies dropped away, until the island kingdom, with two-fifths of the population of France, and a dis-

affected Ireland, stood alone face to face with the mighty onset of the Revolution. Again and again she knitted new coalitions, which were as often cut asunder by the victorious sword of the French army. Still she stood alone, ever on the defensive, until the destruction of the combined fleets at Trafalgar, and the ascendency of her own navy, due to the immense physical loss, and yet more to the moral annihilation of that of the enemy, enabled her to assume the offensive in the Peninsula after the Spanish uprising—an offensive based absolutely upon her control of the sea. Her presence in Portugal and Spain kept festering that Spanish ulcer which drained the strength of Napoleon's Empire; and so, by slow degrees, the greatest military power that has been created in modern times was reduced to impotence.

How the whale thus effected the defeat of the elephant is told at length by Captain Mahan. That the powers of the sea can bring low those of the land is a paradox, and this is, I suspect, one of the reasons why these volumes, although they deal with many matters which do not usually interest lay people, have met with such a general welcome. I need not summarize the course of events, or attempt to show what bearing each one of them had upon the results which were ultimately attained. No one will ever show this better than Captain Mahan himself, and therefore I refer the student to the two volumes, which are published in Boston by Messrs. Little, Brown & Co., and in London by Messrs. Sampson Low, Marston & Co., Limited, and which do not, in my humble opinion, contain a page that cannot be read with pleasure as well as with profit by any man for whom foreign politics, the history of the rise and fall of nations, and the sources of national greatness possess the slightest attractions. My purpose here is first to endeavor to indicate broadly the processes by which, in the period under consideration, Great Britain established the predominance of her sea power; next to show some of the effects which that predominant sea power had upon a military combination that had been at length reduced to absolute maritime impotency; and finally to offer a few conclusions which seem to me to suggest to certain Powers important lessons for the future. I write, as far as possible, from the point of view of the unprejudiced and disinterested observer; from the point of view, if I may be allowed to say so, of a naval expert of neutral nationality; from the point of

view of a publicist who finds in the *Independance Belge* a tribune which is truly independent and truly international; and, above all, from the point of view of one who ardently hopes for continued peace, for increasing commercial prosperity, and for the advancement of civilization.

The naval policy of Great Britain between 1793 and 1805 was not, especially at first, a fixed and steadily pursued one; but experience, aided by the intuitive genius of St. Vincent and of Nelson, at length set it moving along a path which, while the struggle continued, it never again entirely abandoned. One feature in this policy was to spare no pains to improve and to maintain the efficiency of the *personnel*, even at the expense of some amount of deterioration in the *matériel*. The men were kept constantly at sea off the enemy's coasts, were ceaselessly trained, and were, upon the whole, very well taken care of. Service afloat bettered the quality of the men more than it injured the ships, and historically, as Captain Mahan points out, "good men with poor ships are better than poor men with good ships. Over and over again the French Revolutionary wars taught this lesson, which our own age, with its rage for the last new thing in material improvement, has largely dropped out of memory." Another feature—even in the days when a course of action that was mainly defensive had to be followed—was the practice of treating the sea as British territory, and of endeavoring to hold it right up to the shore of the country with which hostilities happened to be in progress. This practice had the effect of giving to the British fleets such advantages as resulted from the tenure of interior positions. A third, and perhaps the most important feature, was the general recognition of the fact that the first duty of a British admiral was to bring the enemy's fleet to action and to destroy it. The traditions of the service did not encourage a commander to attempt great enterprises of territorial conquest until he had either captured the floating foe or driven him into port, and this tradition, which found its most famous exponent in Nelson, was very seldom violated. The tradition was the lodestar of Nelson's glory. In 1798 it led him, after his feverish search of the Mediterranean, into the Bay of Aboukir; in 1801 it enticed him to Copenhagen; in 1805 it took him on that hot chase of Villeneuve. That he might come up with the enemy and drub him was, whenever there was an enemy at sea, his daily prayer and his nightly

dream; and when the enemy was in port, Nelson's grand preoccupation was to induce him to come out and accept battle, or, in default of being able to induce him to come out, to go in and bring him out. Very different was the prevailing French policy. France built better ships than England, and gunned them more heavily, but paid far less attention to the condition of her seamen. After his voyage to the West Indies, Nelson was able to write, "We have lost neither officer nor man by sickness since we left the Mediterranean." At about the same time, as Nelson also tells us, the allied French and Spaniards "landed a thousand sick at Martinique, and buried full that number during their stay." And in 1801, Admiral Ganteaume, addressing his superiors, had to say, "I once more call your attention to the frightful state in which are left the seamen, unpaid for fifteen months, naked or covered with rags, badly fed, discouraged; in a word, sunk under the weight of the deepest and most humiliating wretchedness. It would be horrible to make them in this state undertake a long and doubtless arduous cruise." The Englishmen fought in warm clothes and with full stomachs. Nor had the French the same practice at sea as the English. The standing French order seems to have been: "Husband the fleet in order that we may use it for ulterior purposes: do not risk it in any such dangerous affair as a general action, unless, indeed, you be absolutely certain of gaining a splendid victory. Even if you be not defeated you will damage some of your ships, and so unfit them for the ulterior purposes which we have in view." Often, therefore, for months, and occasionally for years at a time, a French fleet remained in port, steadily deteriorating at its moorings, and sometimes, though in its own protected anchorage, meeting with such an ignominious fate as overtook, in 1809, part of the squadron of Admirals Allemand and Gourdon in Basque Roads. When a French fleet did put to sea, it almost invariably did so for some purpose other than the destruction of the fleet of the foe. If brought to action it fought well, but it very seldom sought action, and frequently—though from no motives dishonorable to its commander—it took pains to avoid it. It is unnecessary to point out which of the two policies is the more likely to breed a competent and confident race of officers and seamen. From the first day of the long war the British Navy began to grow and the French Navy began to decrease, until at last

the island kingdom was almost undisputed mistress of the ocean plains around her.

I say that she was almost undisputed mistress of them; but she could not, and no conceivable maritime supremacy ever can, wholly put a stop to the spasmodic incursions of corsairs and privateers. England had for the nonce annihilated French sea-borne commerce; she had rendered it impossible for France to keep an organized fleet at sea for more than a few days at a time; but she could not prevent French privateers and small cruisers from preying upon British trade. Frenchmen, and some Englishmen, believed the *guerre de course* would wear down or at least seriously cripple Great Britain, and the method of warfare possessed the obvious advantage of being both cheap and profitable; but it proved to be absolutely incapable of producing serious results. While the effect of the naval war, as waged by British policy, was at last decisive and crushing, that of the naval war as waged by French policy never amounted to anything more formidable than an annual tax equal to between two and two and a half per cent. of the British shipping afloat. Under this tax British shipping not merely held its own, but increased enormously. In 1795, Great Britain and her dependencies owned 16,728 vessels; in 1805, 22,051. The prosecution by France of the *guerre de course* did little more than double the ordinary risks of the sea. The damage done was a mere fleabite. After Trafalgar, Napoleon strained every effort to destroy British prosperity by enforcing the continental system. It was his last hopeless struggle against the inexorable influence of sea power. For this purpose, as Captain Mahan points out, edict after edict was issued to France and her allied countries; annexation after annexation was made; a double cordon of French troops lined the shores of the Continent from France to the Baltic; British goods were not only seized, but publicly and wastefully burnt throughout the empire; demands were made upon all neutral states to exclude British manufactures and colonial produce; the calamitous Spanish war was incurred; and the fatal invasion of Russia was undertaken. The game was a terribly costly one. It would have ruined Great Britain had not the sea been hers. It did ruin Napoleon.

Such was the work done by sea power towards the settlement of the most general and tremendous conflict that the modern world

has seen. Sea power, or, to put it otherwise, commercial and naval maritime supremacy, intelligently employed, under the great Pitt and his successors, by St. Vincent, Keith, Nelson, Collingwood, Cotton, and Pellew, who were successive commanders-in-chief in the Mediterranean, and by Cornwallis, Saumarez, Samuel Hood, Strachan, Stopford, and a score more in other capacities, was too much for the most magnificent of military combinations, even though headed by a soldier whose ability was unique, and who in Europe wielded more power, commanded more devotion, and disposed of more forces than any other chief of whom history has left a record. The result was no accidental one. It was necessary: it was inevitable; it was the outcome of the strategical law which exists now as it existed then, but which only now is fully understood.

Captain Mahan's demonstration of this law of the influence of sea power has roused the dockyards of Europe and America to unwonted activity. It seems to have occurred to half a dozen maritime states that all the military advantages resultant from sea power may be secured, at least locally, by the creation of a navy larger and stronger than any of the navies of neighboring nations. This, of course, is an entirely false theory, for sea power does not rest primarily upon the possession of a strong navy, but upon the possession and the maintenance of a superior maritime trade. A navy does not make trade; but trade either makes a navy that is strong enough to support it, or passes into the hands of more provident merchants. Spain had at one time the best trade of the two hemispheres. When she lost her naval supremacy she also lost her trade. The Netherlands inherited Spain's business, but preserved it only so long as the Netherlands navy was equal to the task of its guardianship. Yet it is true that a superior navy, although it cannot make a national trade, can destroy it by causing it to be transferred to a fresh flag; and it is for this reason that the present general activity of the naval dockyards is significant. I do not mean to imply for a moment that it is in the power, even of a superior navy, to conquer trade to itself. After long years circumstances might cause trade to shelter itself under that navy's flag; but it is far more probable that the trade would go at once, not to the conqueror, but to the neutral who happened at the moment to be best able to undertake the responsibility.

If, to imagine an illustration, a naval war were to break out between France and Great Britain, and if the latter were to experience a decisive and crushing defeat at sea, she would lose her trade. But, in the existing circumstances, it would certainly not pass under the control of France. There is no doubt whatever that Germany, which is already the second commercial Power, would immediately become the first. Nor is it likely that Germany would fail to perfect her thus acquired materials of sea power by the speedy creation of a proportionate navy. I do not believe that such a transfer would be less disagreeable to France than it would be to Great Britain; and although I have ample opportunities of perceiving that neither in France nor in any other part of maritime Europe, except perhaps in Italy, is Great Britain regarded with feelings of even tepid friendship, I refuse to suppose that any power would deliberately connive at the obliteration of the United Kingdom for the benefit of Germany. Even Austria would regard with terror so enormous a disturbance of the balance of power.

Unfortunately, France does not appreciate the necessary results, to Germany and to Europe, of a humiliation of Great Britain. She is, moreover, alone among the nations in refusing to accept the law of sea power as it has been formulated and demonstrated by Captain Mahan. France has no definite malign intentions. Of that I am sure. But she chafes at being second instead of first of the naval Powers, especially in the Mediterranean. She will not let slip an opportunity for endeavoring to seize the position to which she considers that she is entitled, and which she fondly supposes would give her sea power in the full sense. And she is making ready accordingly. I do not attach the smallest importance to the individual opinions of that amusing chauvinist, M. François Deloncle, but I know that his utterances at Marseilles on November 4 reflected for once the views of a large number of his countrymen upon the question of the British position in the Mediterranean, and therefore I cite them. "It is a good thing," said the thoughtless deputy, "to remember that the Mediterranean, the Black Sea, and the Red Sea belong to the Latin, the Greek, the Slav, and the Arab races, who are either born on, or have colonized their shores. The Anglo-Saxons are aliens there, and not regular settlers. Neither the Latins, the Greeks, the Slavs, nor the Arabs, will permit them to establish themselves there permanently, for the Anglo-Saxon is their

enemy. This fact is proved by the heap of telegrams which I received from Spain, from Greece, and from Turkey on the occasion of our recent demonstrations at Toulon." M. Deloncle then exhibited telegrams from Barcelona, Cadiz, Seville, Almeira, Athens, Smyrna, and Alexandria, in which occurred such phrases as "Long live the Mediterranean!" "Long live the union of France, Russia, and Spain in the Mediterranean!" etc.

It is this thoughtless and short-sighted impulsiveness of many Frenchmen—who, by the way, know less about Great Britain than about Cochin China—that constitutes the real European danger. I do not speak solely of the danger to Great Britain, but more particularly of the danger to the balance of power, which is now in equilibrium, and to the maintenance of the general peace for which all good men pray. France would pull down England, regardless of, or blind to, the fact that the vacated place would be occupied by Germany. She persists in believing that she could take it. And this is because, as I have said, she will not accept Captain Mahan's law of sea power. The strategical heresis of the "jeune école" of naval officers, headed by Rear-Admiral Reveillère, "Commandant Z," and M. H. Montéchant, are gaining ground among French public men. The new teachers assure them—I quote the recently-published text-book of the "jeune école," "Essai de Stratégie Navale (Berger-Levrault, Paris, 1893)"—that "France can be victorious at sea without battleships, and that she cannot be victorious at sea, and will condemn herself to final defeat, should she attempt to meet battleships with battleships." They declare, again, that the whole art of modern naval warfare consists in the employment of cruisers and light and fast vessels for the work, and that decisive results can be attained by coast-raiding and commerce-destroying. They have not yet succeeded in preventing the construction of battleships. Very many new and magnificent battleships are indeed being built by France as I write, and more are in contemplation. But they have succeeded in obtaining the construction of a vast number of small, fast craft, which could, no doubt, do an immense amount of damage to the commerce of a state like Great Britain, and they have succeeded in persuading a majority of their countrymen not only that France can enter, with prospects of success, upon a *guerre de course* with Great Britain, but also that she may derive substantial and permanent advan-

tages from it in return for a comparatively small expenditure of men and money. Anything that tends to diminish the popular estimate of the seriousness of war is immoral, and anything that tends to obscure the probable results of war is dangerous; and I do not hesitate to say that much of the teaching of the "jeune école" is as wicked as it is foolish. Unhappily, it finds favor in France, where it has created an aggressive chauvinism in the minds of some even of those who do not accept all its dogmas. It is menacing peace; it is encouraging false hopes; and I regret to note that the policy of Great Britain provides daily encouragement of the hot-headed "jeune école," and aggravates the danger of the situation.

I am concerned not for Great Britain but for Europe. Great Britain pretends to the supremacy of the sea, and Europe is, upon the whole, resigned to her enjoyment of it. But British maritime supremacy necessarily jostles and inconveniences many members of the European family; and Europe has a right to demand that so long as Great Britain continues to put forward her claims, she shall support them so determinedly and with such a convincing display of her ability to maintain them as to accustom her envious neighbors to the idea that in a quarrel with her they are foredoomed to defeat. Upon no other terms is her presence in the Mediterranean either tolerable or defensible. If she be obviously weak, her Mediterranean fleet becomes merely a provocation. If she be overwhelmingly strong, her Mediterranean fleet becomes one of the most potent guarantees of peace that Europe can desire; for efficient sea power is as weighty as an argument for peace as it is infallible as a promise of victory.

Efficient sea power—power proportionate to pretentions, proportionate to the interests which are to be guarded! That is no true description of the present maritime power of Great Britain, either in the Mediterranean or elsewhere. I can tell Englishmen that they are very much mistaken if they believe that other nations accept them at their own valuation. I can tell Englishmen that there are as good ships, as good guns, as good men under other flags as there are under the white ensign. I can tell Englishmen that to stamp a thing English is not nowadays sufficient to guarantee its superiority or even its trustworthiness. Great Britain is dreaming while the world is hastening onward with ever-increasing rapidity.

Her sea power has ceased to be convincing, undoubted, recognized. To-morrow it could be shattered, perhaps immediately, by France alone, if only France had no other preoccupations, and if she were assured beforehand of Italy's non-interference. For the citadel of British sea power, the vantage-point upon which rests the centre of the British position in Europe is in the Mediterranean; and, excluded from the Mediterranean, the United Kingdom would, in a few years, be no weightier a factor in international politics than the Netherlands or Denmark. It is scarcely an exaggeration to say that it is only because the Anglo-Italian understanding is generally imagined to be of an extremely cordial and intimate, if not of a formal, nature, that an effort has not already been made to expel the alien whom M. Deloncle openly speaks of as "the enemy." No doubt the good feeling of Italy is very pleasing to British statesmen who have not many friends elsewhere. But it must gall British pride to reflect that British sea power—which, in the old days, was triumphant over an allied continent—is now too decrepit to stand in the Mediterranean without the support of a country which, little more than a generation ago, was disunited and feeble, and which, to this day, has never thoroughly vindicated its claim to consideration as a state of the first class. Upon the danger to Great Britain of relying, even in the smallest degree, upon a foreign country for the maintenance of a situation which is essentially a perpetual source of offence to all the national and racial ambitions of Southern and Central Europe, I will not insist. But upon the risk to the peace of the world which results from Great Britain's illogical and provocative attitude I may say something, for it does not concern Englishmen only. And what I say is: "For the sake of peace, either be strong or have done with your pretensions. In the Mediterranean you are an interloper, and, except for temporary or evanescent purposes, you can call no one there your friend. In the past, I admit, you have done a good work there; you have been upon the whole a benevolent usurper. In the future, if you be adequately strong, you may do an equally good work there, particularly in the direction of preserving peace. But if, while ceasing to be crushingly superior in force, you seek to remain there, you will speedily bring the whole European edifice tumbling about our heads. And you have absolutely ceased to be superior in force there even to France alone."

The *Monthly Navy List* for November notes the names of Her Majesty's ships which, on October 18 last, were then in the Mediterranean. Since that list was published certain alterations have taken place. The Colossus and Inflexible have returned to England, the Ramillies and Howe have gone out, and the Skipjack has been put under orders to go out. We know, therefore, approximately, what will be the constitution of the fighting portion of the British Mediterranean fleet in, say, the middle of December. French official and semi-official documents supply us with particulars of the French naval forces in the Mediterranean. Below I venture to analyze the two lists, a comparison of which will be found exceedingly instructive.

French Mediterranean Fleet, December, 1893.

Class.	Ship.	Age. Yrs.	Tons.	I. H. P.	Men.	Guns: Calibre in Inches.													
						16.5	14.5	13.3	12.5	11.8	10.6	9.4	7.4	6.2	5.5	3.9	2.5	1.8	Mach.
Armored battleship	Formidable ...	8	11,441	9,700	656	....	3	....	....	....	....	....	....	4	....	....	....	12	18
" "	Hoche........	7	10,650	11,300	606	....	....	2	....	....	2	....	....	....	18	....	2	8	12
" "	Dévastation...	14	9,639	8,154	685	....	....	....	4	....	4	....	....	....	6	....	....	2	20
" "	Amiral Baudin.	10	11,380	8,320	656	....	3	....	....	....	....	....	....	4	8	....	....	12	14
" "	Amiral Duperré	14	10,487	8,120	664	....	....	4	....	....	....	....	....	1	14	....	....	6	18
" "	Marceau	6	10,581	12,000	665	....	....	4	....	....	....	....	....	....	17	....	2	12	8
" "	Neptune	6	10,630	12,000	665	....	....	4	....	....	....	....	....	....	17	....	5	....	10
" "	Magenta	3	10,600	12,000	665	....	....	4	....	....	....	....	....	....	17	....	6	14	8
" "	Richelieu	20	8,767	4,240	723	....	....	....	....	....	6	5	....	....	8	....	....	....	18
" "	Colbert	18	8,457	4,652	706	....	....	....	....	....	8	2	....	....	6	....	....	3	14
" "	Caïman	8	7,200	6,000	332	2	....	....	....	....	....	....	....	....	....	4	....	2	16
" "	Indomptable...	10	7,168	6,605	373	2	....	....	....	....	....	....	....	....	....	4	....	2	16
" "	Terrible	12	7,713	6,230	373	2	....	....	....	....	....	....	....	....	....	4	2	2	2
Armored cruiser...	Vauban*......	10	6,150	4,561	436	....	....	....	....	....	....	4	1	....	6	....	2	4	12
" battleship	Courbet*......	12	9,652	8,112	669	....	....	....	4	....	4	....	....	....	6	....	....	6	18
" cruiser..	Bayard*	13	5,986	4,538	450	....	....	....	....	....	....	4	2	....	6	....	2	4	12
" battleship	Friedland*....	20	8,824	4,428	676	....	....	....	....	....	8	....	....	....	8	....	....	2	22
" cruiser...	Dugueselin*...	20	5,894	3,300	450	....	....	....	....	....	....	4	1	....	6	....	....	4	10
" battleship	Redoutable*...	17	8,857	6,071	700	....	....	....	....	....	8	....	....	....	6	....	....	6	16
" "	Trident*......	17	8,456	5,083	730	....	....	....	....	....	8	2	....	....	6	....	....	2	18
" "	Océan*	25	7,750	3,781	686	....	....	....	....	....	....	....	....	....	....	....	....	2	12

Protected cruiser	Alger	4	4,122	8,000	320									4	6		2	8	10
" "	Cécille*	5	5,766	9,600	490									8	10			6	14
" "	Davout	4	3.027	9,000	228									6				4	8
" "	Jean Bart*	4	4,160	8,000	331									4	6		2	10	8
" "	Cosmao	4	1,877	6,000	209										4			4	4
" "	Tage	7	7,045	12,410	546									6	10			5	14
" "	Forbin	5	1,848	5,700	209										4			4	4
Cruiser	Milan	9	1,550	3,986	186											5	1	2	8
Torpedo cruiser	Faucon	6	1,240	3,233	134											5			4
" "	Condor	8	1,240	3.582	134											5		4	4
" "	Vautour	4	1,280	3,391	141											5		6	4
" "	Wattignies	2	1,310	4,000	145											5	2		4
Armored gun-vessel	Achéron	8	1,640	1,700	99						1					3		2	4
" "	Fusée*	9	1,150	1,480	84							1				†1			4
" "	Mittraille*	7	1,130	1,500	82							1				†1			4
Torpedo gun-vessel	Bombe	8	395	2,000	49													4	3
" "	Dragonne	8	395	2,000	49													4	3
" "	Léger	2	450	2,200	91											1		3	2
" "	Lévrier	2	450	2,200	91											1		3	2
" "	Dague	8	395	2,000	49													4	3
" "	Flèche	8	395	2,000	49													4	3

And 81 torpedo-boats.

* These vessels are in reserve at Toulon. Several of them could be immediately commissioned, but some are undergoing repairs or alterations.

† These are 90-cm. (3.5 in.) guns.

In addition, the battleships Jauréguiberry, Bouvines, and Lazare Carnot, and the cruisers Suchet, Linois, and Pascal are building or completing in Toulon or its immediate neighborhood. Among the 81 torpedo-boats are included 8 in Corsica and 19 in Algeria. The majority of them are modern, and some rank among the largest and fastest afloat. It is needless to append the names of the non-fighting French ships in the Mediterranean.

British Mediterranean Fleet, December, 1893.

Class.	Ship.	Age. Years.	Tons.	I. H. P.	Men.	Guns: Calibre in Inches. 16.2	13.5	12.0	10.0	9.2	6.0	5.0	4.0	2.2	1.8	Mach
Armored battleship	Anson	7	10,600	11,500	524		4				6			12	7	7
" "	Camperdown	8	10,600	11,500	526		4				6			12	7	7
" "	Collingwood	11	9,500	9,500	459			4			6			12	8	6
" "	Dreadnought	18	10,820	8,210	440			*4						6	2	17
" "	Edinburgh	11	9,420	7,500	450			4			5			4	10	6
" "	Hood	2	14,150	13,000	650		4				10			10	12	8
" "	Howe	8	10,300	11,500	515		4				6			12	7	7
" "	Nile	5	11,940	12,000	538		4					†6		8	9	6
" "	Ramillies	1	14,150	13,000	620		4				10			6	12	8
" "	Sanspareil	6	10,470	14,000	587	2			1		12			12	9	8
" "	Trafalgar	6	11,940	12,000	550		4					†6		8	9	7
Torpedo ram	Polyphemus	12	2,640	5,500	132									6		2
Protected cruiser	Edgar	3	7,350	12,000	500					2	10			12	5	7
" "	Hawke	2	7,350	12,000	500					2	10			12	5	7
Cruiser	Amphion	10	4,300	5,500	297						10				4	13
"	Arethusa	11	4,300	5,500	297						10				4	10
Protected cruiser	Barham	4	1,830	6,000	151							†6			4	2
Cruiser	Scout	8	1,580	3,200	156							4			8	2
"	Fearless	7	1,580	3,200	156							4			8	2
Dispatch vessel	Surprise	8	1,650	3,000	93							4		4		2
Sloop	Dolphin	11	925	750	100						2	2				3
"	Gannet	15	1,130	800	138						‡2	2	§3			6
"	Melita	8	790	1,200	100							8				8
Torpedo gun vessel	Sandfly	6	525	2,700	61								1		6	
" "	Skipjack	4	735	4,500	85							†2			4	
Gunboat	Bramble	7	715	1,000	73								6			4
Coast Def. ironclad	Orion	14	4,870	2,600	272			‖4						6		8

And twelve torpedo-boats.

* These are 38-ton 12.5-in. muzzle-loaders. † These are 4.7-in. quick-firing guns. ‡ These are 90-cwt. 7-in. muzzle-loaders. § These are 64 pdr. 6.2 in. muzzle-loaders. ‖ These are 25-ton 12 in. muzzle-loaders.

The Orion is in reserve at Malta. In addition there are, belonging to the Mediterranean fleet, the non-fighting ships Cockatrice, police vessel in the Danube; Cruiser, sailing training-ship for seamen; Hibernia, wooden flag-ship at Malta; Humber, store-ship; and Imogene, special service vessel. The twelve torpedo-boats are not modern, and most of them are of small size and of little practical use except in smooth water. They are fitted, moreover, for old types of torpedoes.

The reader may institute comparisons for himself. Should he desire particulars of the thickness of armor, and of the number of torpedo-launching tubes carried by the ships, he can find them and other details in M. Léon Renard's *Carnet de l'Officier de Marine* for 1893, or in Lord Brassey's *Naval Annual*, or in the *Almanach für die k. u. k. Kriegs-Marine*, 1893. And while he is making his comparisons and forming his conclusions, let him not forget that in the Mediterranean Great Britain has no dockyard where she can build anything larger than a sloop-of-war, and that her two naval stations there are in no sense self-supporting, and depend entirely upon Great Britain's ability to supply and succor them by way of the sea. France, on the other hand, has at Toulon a building-yard second to none in the world, a practically impregnable arsenal which has behind it the well-nigh inexhaustible resources of France. She also has private building-yards in the Mediterranean at La Seyne, Marseilles, and elsewhere, and ample dry-dock accommodation. All her reserves of men, money, and raw material are on the spot: all those of Great Britain are two thousand miles away.

At the beginning of this article I hinted my opinion that when all the spare land of the world has been allotted and settled, the value of the sea—thanks largely to Captain Mahan's teaching—will be perfectly appreciated; and that when it is perfectly appreciated, the empire of the sea will be hotly struggled for. British theorists fully accept the great law that has been laid down by the American writer; but the British public neither knows nor cares anything about it. It is apathetic; it is asleep. France, though she does not as yet appear to understand the true principles of sea power, and though she is incapable commercially of securing maritime ascendancy for herself, will certainly not let slip the first favorable occasion for crippling the sea power of England. And she can now cripple it when she will. The situation is one to sorely tempt her natural ambition and her inherited prejudices. If Mr. John Bull is content to sleep himself away into impotence, he will not have any of my humble sympathy when at length he awakes to find that his traditional glory—already slipping from him—has vanished beyond recall. But it is time, I think, for Mr. Bull to be roused and made to understand that, having assumed

certain responsibilities towards Europe, he ought now either to formally abdicate them, ere he goes to sleep once more, or to rise and strengthen himself in order to carry them out. His present policy of pretension and powerlessness in the Mediterranean, is perhaps the most formidable of existing menaces to the peace of the world.

NAUTICUS.

PROFESSIONAL NOTES.

GUN FORGINGS AND ARMOR PLATE IN THE UNITED STATES.

By Russell W. Davenport, Bethlehem, Pa.

[*American Institution of Naval Architects.*]

The high working strains to which modern heavy ordnance is subjected have called for the highest attainable qualities in the material of which the parts are made. To insure this end, the specifications governing the manufacture of gun forgings have been drawn with great care, a large number of test specimens, cut from the actual forgings after final treatment, are required to show uniform and high physical qualities, and the manufacture is subject to constant and thorough inspection. The result is that the steel for gun forgings is melted of the best obtainable material, ingots are cast with special care to avoid cracks, blow holes and other defects, hollow forging is practiced whenever possible, and tempering and annealing is universally applied. In short, all the resources of the steel maker's art have been called upon to insure a perfect product in which the highest attainable physical qualities have been developed. As steel gun forgings have up to the present time been in general made of simple steel, improvements in physical qualities to meet the demands of higher working pressures must be looked for in some steel alloy. Chrome has been used to a limited extent for parts of small dimensions where great hardness and high elastic limit are aimed at, as in the Brown segmental gun, but nickel offers the best promise of improvement in the physical qualities of gun forgings. A complete set of forgings for an 8-inch gun has been made by the Bethlehem Iron Company for the Bureau of Ordnance, U. S. Navy, of nickel steel and are now being assembled at the Washington Navy Yard. The average physical qualities obtained in these forgings in transverse specimens were:

	Tensile strength. Pounds per square inch.	Elastic limit. Pounds per square inch.	Extension. Per cent.	Contraction of area. Per cent.
Tube,	93,200	58,300	21.2	42.0
Jacket,	99,900	60,000	20.4	45.9
Hoops,	109,100	68,200	20.5	46.9

Size of specimen, 2½ inches diameter and 2 inches long.

As compared with an average of qualities usually obtained in corresponding navy gun forgings, made of simple steel, the tensile strength shows an increase of about 10 per cent., and the elastic limit an increase of from 22 to 28 per cent.; the elongation and contraction of area are but slightly reduced.

It is believed that by modifying the composition of this steel a considerably higher tensile strength and elastic limit can be obtained without dangerous sacrifice in ductility.

ARMOR PLATE.

The remarks made regarding the high standard aimed at in the manufacture of gun forgings are also applicable to that of steel armor plate. "The best

is none too good," is a safe motto. Besides meeting certain physical requirements in specimens taken from the plates, the manufacturer has to guarantee a successful ballistic trial of any plate of a group which the inspector may choose to select; and as the financial loss in case of failure may be very great, it is evident that every possible care must be taken to perfect and control the manufacture. The ballistic acceptance test of armor plate for the United States Navy is more severe than that demanded in any other country.

Forged armor plates made of simple steel, as originally developed by the Creusot Works, offered a much greater resistance to penetration than wrought iron or even compound plates when attacked with steel armor-piercing projectiles, but the vice of the all steel plate lies in cracking, and it was the introduction of nickel into the steel, as already stated, which, to a great degree, corrected this defect.

It is probable that an increased resistance to penetration may be obtained by the introduction of other metals along with nickel, and at the St. Chamond Works, in France, steel containing both nickel and chromium has given good results. Developments in this direction, however, have been somewhat checked by the advent of hard faced steel plates, by which it is aimed to stop and break up the steel projectiles before serious penetration takes place.

The introduction of carbon by cementation into the face of the plate with subsequent water hardening, as proposed by Harvey, and known as the "Harvey process," has, up to the present time, given the best results in this direction. The application of this process, which was developed at the Bethlehem Works, with the energetic aid of the Bureau of Ordnance of the United States Navy, has now passed its experimental state for plates of medium thickness, and the Harveyized 12-inch taper plate representing the side armor of the Maine (recently tested at Indian Head), and manufactured by the Bethlehem Iron Company, gave highly satisfactory results, and is beyond doubt the most resisting "service" armor plate ever submitted to trial.

MARINE SHAFTINGS AND ENGINE FORGINGS.

It may be said that in the manufacture of this class of heavy steel forgings it is not yet the usual practice to aim at the highest attainable combination of physical qualities, and that, therefore, there is a wider field for improvement in this direction than in the case of forgings for guns for armor plate.

WIRE-WOUND GUNS.

TAKEN FROM A PAMPHLET ENTITLED "MANUFACTURE OF HEAVY ORDNANCE, WITH SPECIAL REFERENCE TO WIRE CONSTRUCTION," BY W. H. JAQUES, ORDNANCE ENGINEER.

[*A lecture delivered February 9, 1893, before the Massachusetts Institute of Technology, and published in the Technology Quarterly for April.*]

The following is an extract slightly rearranged: "Dr. Woodbridge having been given the credit of priority of invention, and being an American, his plans were adopted and followed until very recently, when two new types, the Crozier, called the Department gun, and the Brown Segmental Tube Wire gun, were recommended for test. The consequence is that one Woodbridge gun was tried and failed, another has been condemned as being of too low power, and three others await trial and completion. One of these is a 5-inch navy breech-loading rifle, awaiting brazing and test. These together with the Crozier and Brown constitute our experimentation in wire-wrapped

ordnance. Other systems and types have been suggested, but difficulties of various kinds have prevented their completion.

"The 10-inch wire-wrapped breech-loading steel rifle built under the supervision of Dr. Woodbridge is practically completed. It consists of a continuous steel tube, overlaid throughout its rear half with a cylinder of closely fitted steel staves, the whole wound with tinned steel wire, to be soldered or brazed in an oven. The whole length of the gun is divided into three sections by steel rings or bands, and forward of the staves the wire is wound directly upon the steel tube. It weighs 30 tons; is 27 feet long; the projectile weighs 600 pounds. The staves were annealed at the Washington Navy Yard. They were 24 feet long, four inches square, and weighed 1290 pounds each.

"The tension of the wire of the Woodbridge gun is adjusted and automatically regulated by a wire-tension apparatus patented by Dr. Woodbridge in 1885. The tensions of winding for the different layers are intended to give, when the interior pressure shall reach a little more than 80,000 pounds per square inch, an extension to the wire overlying the chamber, in all its parts, equal to that due to a tension of 100,000 pounds per square inch in a "free" wire.

"There are two features to the construction which Dr. Woodbridge considers important: to so machine and shape the longitudinal staves as to obtain a condition that will allow the employment of the whole contractile effort of the wire in opposition to the interior pressure, instead of having the resistance of the staves taking a share in it; and to winding wire with a curvature in order to reduce its tendency to unwind if cut. The accomplishment of the former would be accompanied by many mechanical difficulties, while the latter would scarcely seem to meet all the conditions of protection needed against the attack of heavy rapid-fire guns.

"The Board of Ordnance and Fortification, in its report for 1892, states that the Crozier wire-wound 10-inch breech-loading rifle, also known as the Ordnance wire-wound gun, being made from designs of the Ordnance Department, is approaching completion at the Army Gun Factory at Watervliet. This gun, as stated in the former report, consists of a steel tube, overlaid from breech to muzzle with a practically continuous covering of steel wire wound in layers, with a jacket cylinder enveloping the steel wire over the reinforce and a continuous layer of steel hoops covering the wire from the trunnion band forward to the muzzle. The coils of wire are electrically welded end to end, so that the gun is wound with a continuous strand of wire. The breech mechanism is of the usual service type. This high-power gun will be completed, and will doubtless be tested, during the coming year.

"Captain Crozier advocates the use of castings for the jackets, but in this particular gun I believe the jacket is a forging. The general idea of the type is to have the wire as little interrupted as possible by hoops, etc., between the breech and the muzzle; to have the jacket take the longitudinal strain; and to so arrange the general construction that no part except the tube need be of expensive material, without any sacrifice of strength thereby.

"The Brown wire gun consists essentially of a segmental core wound with wire under such tension that the compression between the longitudinal segments of the core induced thereby will be more than sufficient to resist all ordinary powder pressure. The longitudinal segments are primarily held together by a breech and muzzle nut screwed on hot, with the proper degree of shrinkage, so that the tension of the nut and adjoining wire will be the same after winding. The wire is wound between the nuts under a high degree of tension, and anchored by a special device. The trunnions are not attached to the core or body of the gun but to an outer trunnion jacket, which jacket is attached to the gun proper by means of the breech nut. By this means the recoil is transmitted to the trunnions through the breech nut and jacket, and the core or body of the gun is thus relieved from the major part of the longitudinal thrust due to powder pressure upon the bottom of the

bore. The gun itself is free to expand longitudinally within this jacket, which is attached only to the breech nut. The essential feature of the gun is, of course, the segmental core. This core consists of a number of longitudinal steel segments, the number being so regulated that the maximum thickness of a segment shall not exceed one-half inch materially." . . . "The chase jacket consists of a series of interlocking hoops shrunk on over the wire extending from just in advance of the trunnions to the muzzle, the entire jacket being held in place by a muzzle nut, the thickness of which and the amount of shrinkage being so adjusted that when completed the compression produced by the built-up muzzle nut will be the same as that produced by the wire and chase rings.

"During the progress of the work, which has been extended over a period of three years, mechanical difficulties and the results of the trials of experimental cylinders representing sections of the powder chamber gave reason for decreasing the number and increasing the size of the longitudinal segments and the necessity for the insertion of a lining tube to prevent the entrance of the powder gas between the segments, which, in the case of one of the experimental cylinders, was so great as to cause marked discoloration at the joints. The lining tube was inserted under initial tension and extended to about five or six calibers in advance of the front end of the chamber. This tube can be removed and replaced by a new one whenever it becomes too much eroded for service. Recalling the unfortunate experiences of the Maitland half-liners in England, this would appear to be but another invitation for the erosive action of the powder products.

"The advantages claimed for the system are: 1. In consequence of the small weight of each of the component parts of the gun, crucible steel can be used economically. 2. The small size of the segments and the ingot from which they are rolled admit of being carefully cast and uniformly forged, so as to insure uniformity of metal, and of being thoroughly annealed. 3. They can be readily rolled into shape; that is, the method of construction is exceedingly economical. 4. They can be thoroughly and conveniently inspected. 5. The size and thinness of each segment insure a thorough and uniform tempering and annealing, if temper be considered desirable. 6. The size of the segments admits of readily setting up conditions of special elasticity by cold work. This latter feature is by far the most important one in this system of construction, as it renders it possible to use a character of steel far beyond anything heretofore employed in the core of a gun.

"If the segments compressed by the full elastic strength of the wire present an interior surface that can withstand the erosive action of the powder products, we must admit that Mr. Brown has supplied a method of forming the bore of the gun which has decided advantages; but if recourse has to be had to a liner to resist erosion we return to a core that will not sustain the full elastic strength of the wire, and it probably will be more economical to use a steel tube of suitable dimensions than a combination of segments and thin liners, unless these liners, like the segments, are cold drawn, and thus by a great amount of mechanical work rendered impervious to the serious ravages of the powder products.

"Even if the 5-inch experimental gun now approaching completion successfully meets all the conditions that its projector and engineer claim for it, it will still remain to be proved that all the mechanical conditions can be met in guns of larger calibers. The experiment is an interesting one, and if the type is not absolutely new the method of construction is, and all the theory in connection with it is being ably and fluently presented.

"All accidents to wire-wrapped guns point to the absence of adequate longitudinal strength. After a careful consideration of the many devices that have been suggested to meet this defect, that of supplying this quality by long forged steel hoops seems the simplest and most effective.

"When considering the argument so often presented that there will be a

saving of weight, remember that the reduction of weight in the gun must be provided for in carriage and recoil, and that we have now replaced the expression "heavy ordnance" by that of "high power ordnance," because we have gained the power without additional weight of metal, and in many cases by a marked decrease of it. All welding can now be done by electricity; weak spots can thus be avoided and continuous winding easily effected.

"When many of the objections to wire-wound guns were raised wrought iron and iron wire were generally employed, and the mechanical means of shaping and machining were more or less imperfect. Whitworth used some steel, and his mechanical devices led the world but were infants in comparison with present appliances.

"The advantages claimed for the wire system of construction are :

"1. That steel in small sections can be obtained that possesses greater strength than it is possible to get in any other form.

"2. That each layer can be brought truly to its correct tension.

"3. Flaws of manufacture can be easily detected, and if not discovered are confined to that part in which they exist.

"4. The parts of the gun are light and can be more certainly and easily produced and assembled.

"5. For their manufacture expensive and complicated plants are not needed.

"In comparing the reported results of the tests of the various types we must not forget that these experiments have been carried on in various parts of the world, in places very far distant from each other, under different methods, inventors, and circumstances. In the majority of cases they have required to produce them much special machinery which if employed in subsequent production would materially reduce the cost of the guns turned out. In some cases the inventors have been employed to superintend or advise concerning the construction or the preparation of tools or machinery necessary to carry out their special and in some cases peculiar ideas ; all these circumstances have combined to make the cost of the experimental guns very great. On the other hand, the inventors or advocates in estimating the comparative cost and time of production have given themselves every benefit. As these guns have never become commercial service products on any large scale (I believe Russia has manufactured a larger number than any other nation), it is is impossible to make any reliable comparison of their cost and the time required for their production."

PROTECTION AGAINST TORPEDO-BOATS.

CONCLUSIONS DEDUCED FROM ITALIAN NAVAL MANŒUVRES.

[*Royal United Service Institution.*]

Ships should resolutely avoid passing the night at anchor in positions exposed to the attack of torpedo-boats if they have not the means to provide special and efficient systems of obstruction; also, in fortified positions which can only be considered inaccessible to the enemy's ships, obstructions for torpedo-boats are absolutely indispensable, and it will be the best thing to provide them for all passages, bearing in mind that it is better to bar the exterior passages completely rather than the inside channel of access. When the approaches are in this way so closed that only narrow stretches of water remain open, which are more or less permanently illuminated by the electric light projectors and covered by the artillery, the field of fire being constant and localized, there will be very great certainty that no torpedo-boats will be

able to penetrate the defenses. For the land defenses, no dependence can be placed on the projectors unless they are so placed as to permanently illuminate well-defined spaces; the batteries of light guns should be situated at a distance from the projectors so as not to be embarrassed by them, and each one directed to cover with its fire a given illuminated zone and nothing more; the enemy should not be searched for by moving the projectors; the batteries of quick-firing guns should open fire on anything floating which attempted to pass the respective illuminated zones.

In this way the internal service of patrol can be suppressed or very greatly simplified; this service is very difficult to make effective and is likely to give rise to serious inconveniences in the darkness and inevitable confusion of an attack. The movable defense will be most usefully employed exclusively in the service of first discovery of the enemy, and need not come into harbor, unless by day, but will maintain communication by signal with the advanced look-out stations; on occasion, a counter-attack against the approaching enemy might be attempted, obliging him to delay or modify his attack, or to give it up altogether. If all the problems of internal reconnoitring and signaling are suppressed, the exterior guard would be much more simple and efficient, and it would be certain that any floating object discovered by the ships inside the limits would be an enemy. In connection with this subject it may be observed that at the moment of the attack above described, and just at the time when the passes were being forced by the enemy, the Iride opened fire on two of her own torpedo-boats which were thought to belong to the enemy, and would most certainly have sunk them; besides this, one could never be certain that the defending batteries would not mistake one of their own torpedo-boats for one of the enemy's. The anchored ships should be kept ready with their light guns without using their electric light projectors, as the latter, besides revealing the exact position of the ship to any torpedo-boat which might have succeeded in penetrating inside the defenses, are more injurious than useful, either for discovering or battering the enemy. It is not possible to follow the movements of a torpedo-boat effectively by moving the projectors, and it is impossible to open fire on her with any certainty of hitting her; it is, therefore, much better to keep a good look-out and open fire without the projectors. It is certain that a torpedo-boat which has succeeded in entering would have a good chance by charging blindly right against the ships, even at the risk of running ashore; the projectors of the ships would frequently render her final course more certain and secure if they were used. We may reason in the same way on the employment of projectors by squadrons or single ships in the open sea when fearing attack by torpedo-boats; and the fact is indisputable that the electric light at the commencement will render the best service to the torpedo-boats by indicating to them the position of their enemy; and for the rest, the boats will provide for a good result if they are fast, sufficient in number, and ably and boldly directed. The projectors, useful for the defense of passes and approaches, may also serve for the first discovery of the enemy, for dazzling him and rendering navigation, from a hydrographical point of view, most difficult, and also on board ships for signaling at a distance; they should, however, be employed with prudence for the latter service. With regard to the obstructions, if it is possible to construct them, the best will consist of dykes and shoals, leaving very few and narrow channels, as, whatever fittings, instruments, and gear may be invented for the purpose, the best and most infallible means for stopping a torpedo-boat will be an insuffcent depth of water.

TRIAL OF SCHNEIDER'S NICKEL STEEL ARMOR FOR RUSSIA.

[*The Engineer.*]

An excellent statement of the conditions of a recent trial of nickel steel armor, at Creusot, for the new Russian battleship Tria Sviatitelia—Three Saints—appeared in the *Times* of September 9th last. The plate measured 8 ft. by 8 ft. by 15.9 in. It, therefore, probably weighed nearly 18¼ tons. The conditions of acceptance were that it should receive four blows from Holtzer projectiles of chrome steel, weighing 317 lbs. each, fired from a 9.4-in. gun, with a striking velocity of 1945 foot-seconds, without any portion of the plate being broken off, while in no case should the "*base* of the projectile" enter 7.8 in., measured from the face. The exact words used are "penetrate the target to a depth of as much as 7.8 in." The four rounds were delivered at the corners of an imaginary square of 4 ft. sides.

Round 1.—Had a velocity of 2001 foot-seconds; the shot's point entered 14.1-in., and the projectile rebounded "with the point smashed, and the shoulder somewhat set up." "The target showed three very fine cracks running from the wound."

Round 2.—Striking velocity, 1948 foot-seconds; penetration of point, 10.9 in. The projectile rebounded, broken into numerous fragments. Three fine cracks, as before, were developed in the plate.

Round 3.—Striking velocity, 1923 foot-seconds; penetration of point, 14 in. The projectile rebounded with the head smashed, and the cylindrical part somewhat set up. A single fine crack was developed.

Round 4—.Striking velocity, 1962 foot-seconds; penetration of point, 9.9 in. The projectile rebounded, broken into numerous fragments. There were no fresh cracks, and the old ones were not increased.

At the back the bulges behind the points of impact varied from 1 in. to 1.7 in. high. Behind 1 and 2 were some fine cracks.

To Messrs. Schneider is the credit due of having first applied nickel to the manufacture of armor, and of having been long the sole manufacturers of through steel armor, which is now universally approved. Rare indeed is it for Messrs. Schneider to make a bad plate, and this plate is a very good one indeed. Messrs. Holtzer's projectiles have long been taken as the standard of highest excellence. These facts being so, it is interesting to compare the above trial with recent American and English results. In a trial which took place at Indian Head, on July 11th last, a Bethlehem all steel nickel-plate, 17 in. thick, was attacked by a 12 in. gun, firing forged-steel Carpenter projectiles with varying velocities. The second round most nearly corresponded to the results now before us. The velocity was much lower, namely, 1495 foot-seconds, but the theoretical penetration and the shock per ton were not so much less as to prevent comparison. On the English system the theoretical conditions are as follows: Schneider plate, 3d round, theoretical perforation through iron 17.36 in., the plate being 15.9 in. thick. Bethlehem plate, 2d round, theoretical perforation 19.18 in., the plate being 17 in. thick. The energies per ton of plate were respectively 483 and 425 foot-tons. The Schneider plate was therefore more severely tried as to fracture, and it may be noted that it exhibited a slight hair crack. The shot entered much more deeply in the Bethlehem, which, we think, was decidedly softer than Schneider's; undoubtedly both plates were excellent. To come to the projectiles, it can hardly escape observation that Holtzer's larger projectiles do not behave as well as those for his 6-in. gun. It may be well expecting a good deal to ask that 9.4-in. projectiles should rebound intact after impact at over 1900 ft. velocity on steel, although the 6 in. projectiles will often do this. The Carpenter 12-in. projectiles rebounded apparently uninjured from the Bethlehem

plate at, after striking, 1838 ft. velocity. It may be urged that the Bethlehem plate was rather softer, and at this velocity it was over matched. Still, making all allowance, the fact remains that, putting fracture aside, the Holtzer 8-in. projectiles at Indian Head, America, have been regularly and symmetrically setting up, and here, on this occasion, the 9.4-in. projectiles in two cases set up as well as breaking up. A projectile ought not to set up under any circumstances. Consequently, we think that Holtzer's larger projectiles cannot at present claim at all the high character that the 6-in. ones have maintained.

LENGTHENING A LARGE OCEAN STEAMER.

[*Engineering.*]

The North German Lloyd's mail steamer Bayern, which has just gone out from Southampton for China has been lengthened to the extent of 50 ft., and her tonnage increased to 5600 tons. The vessel was found too small for the eastern trade, and it was decided to lengthen her, and the ship was handed over to Messrs. Blohm and Voss, in Hamburg. She was placed in dry dock, and was severed amidships forward of the engine-room. The fore part was drawn forward 50 ft. by specially devised hydraulic gear, and a complete water-tight compartment 50 ft. long built to connect the two parts, and the necessary strengthening effected. The Bayern is now 450 ft. long, and in the new part a main saloon was reconstructed, the other public rooms being rearranged and enlarged. The addition to the cargo-carrying capacity is 8476 cubic feet, while a larger number of passengers may be carried. A sister ship, the Sachsen, is now being lengthened in the same way. Of course many such lengthening operations have been carried out, the P. and O. Company having lengthened several of their boats in recent years, while the Union Company are having the Moor lengthened by Messrs. Thomson. Nevertheless, this is another step forward of the German shipbuilders, for nothing of this nature on such a scale has hitherto been tried.

EXPERIMENT ON A SUBMARINE BOAT.

At Newport, on December 16th, an experiment was made in submarine explosion. A torpedo-boat, cigar-shaped, was submerged 15 ft., and in it were placed a pair of pigeons, a pair of rabbits and a pair of cats. About 430 feet away from the boat, and submerged at an equal depth, was a torpedo containing 76 lbs. of gun-cotton. This torpedo was fired by an electric current.

On approaching the submerged boat a quantity of bubbles were found to be ascending, which indicated that the boat had been ruptured, and on examination the boat was found to have sunk.

RAMMING A DERELICT.

A most profitable experiment is said to have been executed by the San Francisco, October 2, on her way from New York to Key West. Right in the track of commerce she found a lumber-laden schooner afloat. Boats were sent to fasten gun-cotton torpedoes to the hulk, and these were attached at

different places so as to hang beneath the keel. They were exploded by electricity, but ten of them failed to break the vessel up and release her cargo, the latter being waterlogged and jammed.

Finally, after officers and crew had worked from early morning until evening to destroy the worthless craft, Capt. Watson of the San Francisco made up his mind to resort to war methods. Calculating his distance at about a quarter of a mile, he put on a full head of steam and aimed his ship straight at the derelict. Striking her at full speed, the steel beak of his ship passed through the schooner like a knife through paper, cutting it in two amidships. It was a fair illustration of the irresistible power of the ram. The halves of the hulk drifted apart, and to make the work complete, half-a-dozen shells were fired into the after part, breaking it up.

SHIPS OF WAR OF THE UNITED STATES.

THE COLUMBIA.

The board to conduct the official trial of the U. S. S. Columbia report that she is sufficiently strong and well built in all particulars to meet the requirements of the specifications; that the mean speed of the ship in two runs over a course of 43.968 geographical miles was 22.80 knots an hour under forced draft, with average air pressure of nine-tenths of an inch, due allowance being made for the tide. So far as could be determined from the brief experience of the trial, the Columbia possesses in a marked degree the qualities of steadiness, seaworthiness and ready obedience to her helm. The performance of the engines, boilers and dependencies was excellent. The board noted with satisfaction the ready obedience of the vessel to her helm and that during the run the ship was well steered from point to point of the course. The vibration was greater than was observed on the trial of the New York, but no greater than should be expected of a vessel of such length and great power of engines. It appeared to reach a maximum at from 85 to 95 revolutions per minute; at a higher speed diminished somewhat. While at full speed on this passage with two screws the helm was shifted from amidships to 30 deg. starboard in 10 seconds, and from 30 deg. starboard to 30 deg. port in 17 seconds. Trouble was found, however, in water collecting in steering cylinders.

The chief dimensions and particulars of her are: Length on load-line, 412 ft.; moulded beam, 58 ft.; mean normal draught, 22 ft.; displacement, 7350 tons; indicated horse-power, 21,000; coal capacity with normal draught, 750 tons; maximum coal capacity, 2000 tons; radius of action at 10 knots, 26,240 miles; guaranteed sea speed, 21 knots. The magazines, engine-rooms, and vitals are protectected by an over-all steel deck, varying from 2½ in. to 4 in. thick. One screw is immediately before the rudder, on the centre line of the ship, and is a four-bladed screw of 10 in. more pitch than the two others, which are placed one on each quarter, 15 ft. forward of the middle screw and 4 ft. 6 in. above it. These are triple-bladed. Each screw has independent triple-expansion vertical inverted engines. With the middle screw alone a speed of 15 knots can be attained; with the quarter screws alone a speed of nearly 19 knots. Steam is supplied by eight main boilers, placed in four separate compartments, and carrying 160 lbs. per square inch as their working pressure. The armament, in addition to six torpedo ejectors, is to be composed of one 8-in., two 6-in., twelve 4-in. rapid-firing, sixteen 6-pounder rapid-firing, eight 1-pounder rapid-firing rifles and four Gatling guns. The 8-in. gun will be mounted as a chaser; the 6-in. guns will be mounted one on each bow; the 4-in. guns will constitute the broadside armament. The subdivisions of the vessel, which is furnished with a ram, are so arranged as to form a complete double hull below the water line.

THE OLYMPIA.

The U. S. cruiser Olympia was launched at the Union Iron Works, San Francisco, on November 5, 1892. She is practically an improved Charleston. Her principal dimensions and particulars are: Length on water-line, 340 feet; breadth molded, 53 feet; normal mean draught, $21\frac{1}{2}$ feet; displacement corresponding, 5500 tons; indicated horse power on trial estimated, 13,500; guaranteed speed on trial, 20 knots; sustained sea speed, 19 knots; maximum coal capacity, 1300 tons; complement of men, 463. A complete protective deck is worked 2 inches thick on the flat throughout, $4\frac{3}{4}$ inches on the slopes amidships and 3 inches on the slope forward and aft. A water-excluding belt 2 feet 9 inches thick extending 4 feet above the water-line is worked above the protective deck, completely surrounding the ship. The engines are vertical, direct-acting, triple-expansion, driving twin screws. The cylinders are 42.59 and 92 inches in diameter, by 42 inches in stroke, and it is expected that the I. H. P., will be 13,500. There are six steel boilers, designed for a working pressure of 160 pounds, each 15 feet 3 inches outside diameter, with shells $1\frac{19}{64}$ inches thick; four are double ended and 10 feet $11\frac{1}{2}$ inches long. Forced draft is by closed fire-rooms, and there are two smoke-pipes.

The battery consists of four 8-inch breech-loading rifles, ten 5-inch rapid-firing guns, twenty-four 6-pounder rapid-firing guns, six 1-pounder rapid-firing guns, four Gatlings and six torpedo-tubes. The 8-inch guns are mounted on the main deck forward and aft on the centre line in elevated barbettes 4 inches thick, with turrets around the guns. The latter are about 10 feet above the deck and have very great train.

The Olympia left her anchorage at Santa Barbara, Cal., at 6.30 A. M., Dec. 15, and took a run of about two hours before starting on her official trial. The ocean was like a big mill pond, and was only ruffled by the cruiser herself as she sped through the water, sending spray over her bow until the decks were dripping. From Goleta Point to Point Conception quite a swell was running, but not enough to retard her headway to any extent. The machinery worked perfectly, and during the trial there was not the slightest break. She made a corrected mean speed of 21.6 knots. This will give her builders a bonus of $300,000, the highest premium yet earned by one of the new ships. The draught was 4 in. greater than the requirements. She maintained nearly the same speed from one end of the course to the other, making no notable spurts. Being pressed over the whole course, the highest which she reached was 22.2. An average of 140 revolutions was made—the highest was 142 and the lowest 137—under steam pressure of 165 to 168 pounds.

At 1:09:30 the Olympia finished her trial trip. Before returning to the harbor, she put out to sea for the purpose of testing her steering gear.

THE MARBLEHEAD.

The U. S. cruiser Marblehead realized on her trial a mean speed of 18.44 knots. The contractors intended to have a second trial, as a speed of 18.5 knots would have given them a premium of $150,000, or $25,000 more than they will get under existing conditions; it is to be remembered that the sister ship Detroit made 18.7 knots. But the cost of fitting out the observation vessels, which would have been charged to them, the cost of the trip and the risk of a break-down have deterred them from making a second effort and she will become a part of the Navy with her record as it stands.

LAUNCH OF THE OREGON.

The U. S. coast-line battle-ship Oregon was successfully launched from the yard of the Union Iron Works, at San Francisco, Cal., on Thursday, Oct. 26.

The Oregon is one of the three ships the bids for which were opened at the Navy Department on October 1, 1890. The two sisters of the Oregon are the Massachusetts and Indiana, both of which have been constructed at the yard of the Messrs. Cramp in Philadelphia.

By a provision of the act of Congress authorizing their construction it was directed that one of the three vessels should be built on the Pacific coast, and the contract was awarded to the Union Iron Works, of San Francisco. The appropriation for each ship was $4,000,000, exclusive of armament. The Oregon is similar in all respects to her sister vessels.

LAUNCH OF THE CINCINNATI.

The Cincinnati was launched Nov. 10, at the New York Navy Yard.

GUNBOATS 7, 8 AND 9.

Gunboats 7, 8 and 9 are to be built by the Newport News Co. Their bid for the three vessels was $840,000.

ENGLAND.*

THE REVENGE.

The principal dimensions of H. B. M. first-class battleship Revenge are as follows: Length 380 feet, beam 75 feet, load displacement, at which she has a mean draught of 27 feet 6 inches, 14,150 tons. She has been fitted by her builders with triple-expansion twin engines, to indicate 9000 horse-power under natural draught and 13,000 under forced draught, supplied with steam from eight circular single-ended boilers, each having four furnaces, the total heating surface being 21,600 square feet. The working pressure is 155 pounds per square inch.

As the ship was light in the water by fully 2 feet of her designed load draught—27 feet 6 inches—the speed results on the trials do not of course agree with the calculated ones; but the mean results attained with the vessel at her mean draught of 25 feet, on the eight hours' natural draught full power trial, on November 7, were as follows: With an air pressure of only .19 inches in stokeholds, steam was maintained at 149.8 pounds pressure per square inch, the vacuum in starboard and port engines was 28.5 and 28.3 inches, the corresponding revolutions 96.3 and 96.8 per minute, and the resultant indicated power developed by them 4614 and 4563 respectively, or a total of 9177 horses, being 177 in excess of that contracted for, the average speed with this power attained by the ship being 17.375 knots an hour by log.

The mean results attained on the so-called forced draught trial on the 9th Nov.—the air pressure in the stokeholds being only .46 inch—were as follows: The steam pressure was 146.8 pounds per square inch; the vacuums, 28 and 28½ inches; the revolutions, 101.6 and 102.3; and the developed indicated power, 5694 and 5830 horses for the starboard and port engines respectively; the resultant speed of the ship by log being reported to be 17.5 knots per hour. The gross horse-power indicated on this trial, it will be seen, amounted to 11,524 horses, showing that under ordinary conditions of working—wherein half an inch of air pressure is always allowed to the contractor—the full designed power of 13,000 horses could be easily developed under the greater air pressure used on the trials of similar ships prior to the developed testing power being reduced by Admiralty order to 11,000 horses.

* The particulars of foreign ships of war, except those of the Re Umberto, are taken from *The Engineer* or *Engineering*, or both.

THE BARFLEUR.

The Barfleur, first-class battleship, sister ship to the Centurion, built at Chatham and engined by the Greenock Foundry Company, is with her sister a pair of battleships of a new type, and of smaller size than the Revenge. Her general dimensions are: Length 378 feet, breadth 70 feet; load displacement 10,590 tons, with a draught of 25 feet 6 inches. She is fitted with triple-expansion twin engines to develop 9000 indicated horse-power under natural draught, and 13,000 under forced draught. There are eight circular boilers with four furnaces in each, made for a working pressure of 150 pounds per square inch. The tubes are 2½ inches diameter, fitted with cup ferrules at the fire-box ends.

The full power natural draught trial which was to have been of eight hours' duration, but through darkness coming on, was curtailed to seven, took place on the 9th Nov., at which the following mean results were attained: The stokeholds being under no air-pressure throughout the day, steam was maintained at 148.5 pounds pressure per square inch, the vacuum was 27.3 inches and 27.7 inches; the revolutions 95.3 and 95.9 per minute, and the developed indicated powers 4962.2 and 4932.2 horses for the starboard and port engines respectively, or an aggregate power of 9894.4 horses, giving the ship a speed of 17.165 knots per hour by log.

The continuous four hours' full power trial under forced draught took place on the 11th Nov., and gave the following mean results: With an air pressure of 1.4 inches steam was maintained at a mean pressure of 142.4 pounds per square inch, the vacuum reached 27.7 inches and 27.4 inches, the revolutions were 104.8 and 105.6 per minute, and the developed indicated powers were 6580.4 and 6582.7 horses in the starboard and port engines respectively; the total power of 13,163.1 horses giving the ship a speed of 17.537 knots per hour. It will thus be seen that the excess of power developed by the engines over that contracted for was 894 horses in the natural and 163 in the forced draught trials; a result which was considered highly satisfactory, as in the case of the natural draught trial a maximum power of 10,615 horses was developed in one hour, and 10,070 horses for two consecutive hours, notwithstanding that the wind was high and the sea very rough.

THE CENTURION.

On October 6, 1893, H. B. M. S. Centurion, went out for her steam trial under forced draught. The average deep sea speed of ship, as recorded by log, was 18.51 knots, which, though believed to be below the actual performance, is the greatest speed which has hitherto been attained by an armorclad.

The Centurion, which was laid down at Portsmouth in March, 1891, and engined by the Greenock Foundry Company, went out September 19, for her contractors' eight hours' trial with natural draught. She is of 10,500 tons displacement, and forms, with her sister ship, the Barfleur, a distinct type of first-class battleship. Of light draught compared with most armorclads of her size, she was designed to be able to pass through the Suez Canal with a large quantity of coal on board, being in all other respects fully laden. Her mean load immersion is 25 ft. 6 in., and her estimated speed in this condition, under natural draught is 17 knots. Her trim on trial was 25 ft. forward and 26 ft. aft, so that the average draught was exactly that of her designed draught. The trial proved eminently satisfactory. With a boiler pressure of 146½ lbs. and a mean of 96 revolutions the starboard engine developed 4785 and the port engine 4918 horses, or a total collective horse-power of 9703. The contract was for 9000. The mean air-pressure amounted to 0.18 in., and the coal consumption to 1.9 lbs. per indicated horse-power per hour. The average speed realized during the eight hours' steaming was 17½ knots by log.

THE HAVOCK.

The new torpedo-boat destroyer, Havock, on her first trial, October 28, 1893, in bad weather, realized a mean speed of 26.78 knots per hour, the engines, with steam at 165 lbs. pressure, making 362 revolutions per minute, and indicating 3400 horse-power; the air pressure in the stokehold during the trial—which was of three hours' duration—seldom exceeding half of that allowed—5 in.—by the Admiralty in this class of vessel. This trial, which was considered by the officials present highly successful and conclusive as a test of speed, was followed on November 3, by an eight hours' steaming trial for the purpose of determining the coal endurance and radius of action of the vessel at an economical speed. With sixty tons of coal—her ordinary bunker capacity—it was found that a ten-knot speed could be maintained with 3½ cwt., and that at eleven knots the consumption would not reach a quarter of a ton per hour, thus enabling the vessel to cover at least 3500 knots before it would become necessary to re-coal her. The official trials are thus satisfactorily concluded, the last one, of course, not being intended either as a test of speed or of power developed, but merely to show the capabilities of the vessel under ordinary conditions of working.

In appearance, the Havock looks but little different in form and size from a first-class torpedo boat of the Yarrow type. Her dimensions are: Length 180 ft., breadth 18 ft. 6 in., and displacement at a mean draught of 6 ft. about 210 tons. She has but one deck, at the forward end of which is a long turtle-back covering in a lofty forecastle, in which the greater part of the crew is berthed. The middle part of the vessel is occupied by the engines and boilers, and in the after part are the artificers' and officers' messrooms and berths. She is fitted with triple-expansion twin engines, each having three inverted cylinders of 18 in., 26 in. and 39½ in. diameter, and 18 in. piston stroke, capable of developing 3500 indicated horse-power, which are supplied with steam by two locomotive type marine boilers, fitted with copper fire-boxes and copper tubes, having a total heating surface of about 5000 square feet, and a grate surface of 80 square feet; the boilers being designed for a working pressure of 180 lbs. per square inch, and capable of generating sufficient steam for 3600 horse power.

The Havock is armed with one 12-pounder quick-firing gun placed on the forward conning tower, and having a practically all-round range; two similar 6-pounder guns, one on each side; and one 6-pounder gun on a high mount, near the stern. Three 18-in. torpedo tubes are also fitted, one being fixed in the stem for right ahead firing, and the other two swiveling, for side firing. With her high speed and powerful armament, the Havock, it is inferred, will be capable of overhauling the fastest torpedo-boat now afloat, and able to cope with any two of them. From the marked success attained by her on her official trials, the authorities at the Admiralty have since ordered no less than thirteen similar vessels to be constructed by leading builders of such ships, which, when completed, should put the British Navy in a position to cope with the torpedo flotilla of any power.

THE THESEUS.

The official full power trial of the Theseus was successfully completed December 20, when with the engines running for seven consecutive hours, with a mean boiler pressure of 149.4 lb. per square inch, maintained with .43 in. of air pressure, they attained a mean speed of 96.2 and 96.3 revolutions per minute, the vacuum being 27.24 and 27; and developed 5315 and 5293.4 horse power in port and starboard engines respectively, or a gross indicated horse-power of 10,608.46, being 608.46 in excess of that contracted for, giving the ship, which had a mean draught of 23 ft. 3½ in. at the time, a speed of 18.66 knots an hour by log.

The Theseus is of the same dimension as her sister ship the Grafton, viz.: 360 ft. long, 60 ft. beam, and 7391 tons displacement, at which her mean draught is 23 ft. 9 in. She is fitted with independent twin engines—in separate engine-rooms—of the inverted three-cylinder triple-expansion type, each engine driving a three-bladed screw propeller of 16 ft. 9 in. diameter. Steam is generated in eight single-ended four-furnaced circular tubular steel boilers, each 16 ft. 2 in. diameter, and 9 ft. 10 in. long, having a total heating surface of 24,416 square feet, and a grate surface of 730 square feet, all made for a working pressure of 125 lbs. per square inch.

Throughout the official trial the weather was very rough, it blowing half a gale of wind all day with a heavy sea, and as more than half of the trial was done against both, it was considered a highly successful and satisfactory one.

THE ROYAL OAK.

The Royal Oak is the last of the eight battleships ordered in 1889; four of which were to be built and engined by contract, the hulls and fittings of the remaining four being built in the Royal Dockyards, and fitted by contractors with their main and auxiliary machinery. The whole of them have now passed the ordeal of their official machinery trials with very great success.

The principal dimensions of the Royal Oak are: Length, 380 ft.; breadth extreme, 75 ft.; displacement at a mean draught of 27½ ft., 14,150 tons. Her propelling machinery consists of two sets of triple-expansion twin engines, each having three inverted cylinders of 40-in., 59-in. and 88-in. diameter respectively, with a piston stroke of 51-in. They each drive a four bladed gun-metal screw propeller 17-ft. diameter and 18-ft. pitch. The engines are designed to develop 9000 indicated horse-power under natural, and 11,000 under forced draught. Steam is supplied by eight single-ended circular Scotch boilers, each 15 ft. 4 in. in diameter, and 9 ft. 4 in. long, having four corrugated furnaces 3 ft. 4 in. in diameter; the total heating surface being 20,174 square feet, and the grate surface 710 square feet. The cooling surface in the main condensers is 14,500 square feet.

The propelling engines of the Royal Oak are similar in design to those of the other seven battleships built under the Naval Defence Act, but have that difference in detail which is invariably found in engines by different makers; the steam cylinders in her case being supported in front and rear by round steel columns well stayed together and stiffened by cross bracing. As in all modern first-class engines, the crank shafts are in three pieces bolted together, but made interchangeable. Piston valves are fitted to the high and intermediate pressure cylinders, and ordinary double-ported flat valves to the low-pressure ones, all the valves being actuated by double eccentrics and twin bar link motions, the reversing gear being of the all-round type.

DETAILS OF RESULTS OF STEAM TRIALS OF NAVAL DEFENSE ACT BATTLESHIPS.

[*Engineering.*]

Ships.		Draught of Water.		Displacement.	Indicated Horse-Power.			Speed by Log.
		Forw'd.	Aft.		Starb'd	Port.	Total.	
		ft. in.	ft. in.					knots.
Royal Sovereign........	N. D	27 0	28 0	14,260	4,928	4,733	9,661	16.375
	F. D.	26 8	28 0	14,150	6,653	7,710	13,363	18.
Royal Sovereign..	4 runs M. M.	27 0	28 0	14 260	4.879	4,597	9,476	16.32
	"	27 8	28 0	14,260	4,935	4,844	9,779	16.77
Empress of India.......	N. D.	25 4	26 4	13,210	4,762	4.746	9,508	15.25
	F. D.	24 11	25 9	13,070	5,978	5,647	11,625	18.
Repulse................	N. D.	22 5	25 9	12,100	5,000	4,588	9,588	17.78
	F. D.	22 5	25 9	12,100	5.997	5,518	11,315	18.2
Hood..................	N. D.	25 6	27 4	13,580	4,636	4,903	9,539	15.75
	F. D.	25 3	27 4	13,500	5,694	5,752	11,446	16.9
Ramillies...............	N. D.	24 3	26 1	12,800	4,718	4,725	9,443	16.75
	F. D.	24 3	26 1	12,800	5,847	5,724	11,571	17 25
Resolution	N. D.	24 4	25 9	12,730	4,592	4,656	9,248	16.73
	F. D.	23 10	25 8	12,530	5,683	5,718	11,401	17.92
Revenge...............	N. D.	24 2	25 9	12,680	4,614	4,563	9,177	17.375
	F. D.	24 1	25 8	12,610	5,694	5,830	11,524	17.5
Royal Oak...........	N. D.	24 6	25 6	12,690	4,477	4,744	9,221	16.5
	F. D.	24 4	25 5	12,610	5,689	5,882	11,571	18.27
Centurion *......... ...	N. D.	25 0	26 0	10.590	4,785	4,918	9,703	17.5
	F. D.	25 0	26 0	10,590	6,401	6,773	13,174	18.51
Barfleur *	N. D.	21 6	25 6	9,500	5,003	4,931	9,934	17.165
	F. D.	22 0	25 6	9,650	6,580	6,583	13,163	17.537

LAUNCH OF H. M. S. FORTE.

A further addition was made to the British Navy by the launch from Chatham Dockyard of the new second-class protected twin-screw cruiser Forte, one of the group of eight of the same class ordered to be built under the Naval Defence Act of 1889 in the Royal dockyards. Her first keel-plate was laid on September 2, 1891, and she is of the following dimensions: Length between perpendiculars, 320 ft.; extreme breadth, 49 ft. 6 in.; and displacement, at a mean draught of 19 ft., 4385 tons. Her hull, with the exception of stem, stern and rudder posts, is built of steel. Like other cruisers of the same class, she has no side armor, but is fitted with a steel protective deck throughout her length, and has an armored steel breastwork 5 in. thick for the protection of her machinery; and being intended for foreign station service, is wood-sheathed. She will be fitted with triple-expansion three-cylinder twin engines constructed at Chatham Dockyard, designed to develop 9000 indicated horse-power under forced draught, with which she is expected to attain a speed of 19½ knots an hour. Steam will be supplied by eight single-ended three-furnaced circular boilers, made for a working pressure of 155 lbs. per square inch. The Forte will be armed with two 6-in., eight 4.7-in. and eight 6-pounder quick-firing guns, seven .45-in. machine—Maxim—guns, and one 3-pounder and one 9-pounder rifle muzzle-loading guns. She will also be fitted with two fixed 14-in. torpedo tubes—one being in the stem, and one at the stern, for fore-and-aft firing; and two swiveling tubes of the same size for side firing.

* The Centurion and Barfleur are of a different type from the others.
N. D. means natural draught, and F. D. forced draught, the duration of the trial under the former condition being eight hours, and under the latter four hours.

FRANCE.

LATE ADDITIONS TO THE FRENCH NAVY.

Four new warships have been added to the navy of France, named respectively the Charles Martel, the Bugeaud, the D'Iberville and the Lansquenet. Of these, the Charles Martel, built at Brest, is a first-class battleship, the largest as yet built in France. Her dimensions are: Length, 380 ft. 6 in.; breadth, 72 ft. 1 in.; and displacement, at a load draught of 27 ft. 6 in., 11,822 tons. She is to be propelled by twin screws, driven by engines of 13,500 indicated horse-power, which are expected to give her a maximum speed of 17¾ knots. She has a steel protective deck over her machinery and boilers, 2.7 in. thick. Her armor belt is of steel, of a maximum thickness of 17¾ in. At either end of her central battery is an armored turret, made of steel plates, 14½ in. thick, in which is mounted a single 11.8 in. 44-ton gun, and on each broadside, sponsoned out so as to admit of fore-and-aft fire, is a turret, armed with a single 10.6-in. 34-ton gun. In lighter turrets, also on each broadside, are fitted four 5½-in., and in the upper works and tops four 9-pounders, twelve 3-pounders and eight smaller quick-firing guns. The vessel has a bunker capacity for 800 tons of coal, and she is estimated to cost, when completed, £987,000. The second vessel, the Bugeaud, is a second-class protected cruiser of the largest type, being 308 ft. in length, 42 ft. 6 in. beam, and having at a draught of 20 ft. 10 in. a displacement of 3722 tons. Her engines, which drive twin-screws, are of 9000 indicated horse-power, and designed to give a maximum speed of 19.2 knots per hour. There is a steel protective deck 2.4 in. thick over her whole length. Her armament consists of six 6.2-in., four 3.9-in. and eight 3-pounder quick-firing guns, together with twelve 1-pounder machine guns, and six torpedo tubes. The bunker capacity of the vessel is 600 tons, and she is estimated to cost, complete, £260,300. Of the two other vessels lately launched, the D'Iberville, built at Saint Nazaire, is a torpedo catcher, of a type the nearest equivalent to that of the British Alarm. Her dimensions are: Length, 262 ft. 3 in.; breadth, 26 ft. 2 in.; and displacement at an 11 ft. 1 in. draught, 925 tons. She is to be fitted with engines to develop 5000 indicated horse-power, estimated to give her a maximum speed of 21½ knots, which are to be covered with a light protective deck 6 in. thick. Her armament will be one 3.9 in., three 9-pounders and four 1-pounder quick-firing guns. She will also be fitted with six torpedo tubes. Her cost, when completed, will be £117,960. The fourth vessel, the Lansquenet, built at Nantes, will be the largest and fastest of the French sea going torpedo-boats. She is 163 ft. 3 in. long, 15 ft. 7 in. beam, and at a draught of 4 ft. 2 in. will have 138 tons displacement. She is to be fitted with engines of 2800 indicated horse-power, driving twin-screws, and she is expected to attain a speed of 26 knots an hour.

ITALY.

THE ARETUSA.

The Aretusa is a torpedo gun-boat 230 ft. long by 25 ft. 6 in. beam, and at 11 ft. 9 in. draught displaces 740 tons. Her armament consists of one 12-centimetre gun, six 6-pounders and three 3-pounder quick-firing guns, and three machine guns. She can launch five torpedoes simultaneously.

The total weight of engines, boilers, water, spare pieces, etc., is 173 tons, making about 86 lbs. per indicated horse-power. The stroke is very short, owing to the necessity of bringing the cylinders below the protective deck.

The principal dimensions of the cylinders are as follows :

Diameter of high-pressure cylinder	0.590 m. (23.23 in.)
Diameter of intermediate pressure cylinder	0.919 m. (36.18 in.)
Diameter of low-pressure cylinder	1.375 m. (54.13 in.)
Stroke	0.460 m. (18.11 in.)

The shortness of stroke does not involve any inconvenience in working, which is smooth and regular. The engines are placed in two separate compartments, the reversing and starting gears being in the centre, and the condensers placed at the sides of the ship.

The propellers' bosses are of gun-metal, with blades of Stone's patent bronze, the diameter being 2.400 metres (8 ft.), and the pitch 2.760 metres (9 ft. 0.66 in.).

The low-pressure slide valves are fitted with Joy's assistant cylinders, this being their first application in Italy. Each of these developed during the trials 8 to 10 indicated horse-power. The slide valve and rod weigh 326 kilogrammes (718.7 lbs.). The low-pressure eccentrics worked smoothly, and did not show any indication of heating at a speed of 270 revolutions.

The boilers, four in number, of the open-bottom locomotive type, are placed two forward and two aft of the engines, the former supplying the port and the latter the starboard engines. The total heating surface is 782 square metres (8417.68 square feet), and the firegrate surface 17.28 square metres (about 185½ square feet). The air blast is delivered under the grates through a closed ashpit, each boiler having its own funnel of 1.60 metres (62.90 in.) in diameter. The boilers proved very satisfactory. No leakage, priming or other defect was noticed under natural or forced draught steaming.

On the trial under natural draught the mean average of the revolutions indicated by the continuous recording apparatus for the ten hours was for the port engine 218.7 revolutions, and for the starboard engine 218.5 revolutions. The distance of 72 miles from the Meloria to Nervi, in the Gulf of Genoa, was run in 3 hours 59 minutes, giving a mean speed of 18.06 knots. The ship was then turned and put on her return course, completing her trial at 4.15 P. M., south of Leghorn, without a single hitch during the whole of the ten hours' run. The mean indicated horse-power for the ten hours was 2129, being 129 over the contract. The vibration of the hull was very slight.

The forced draught three hours' trial was also successful. The contract power to be obtained on this trial was 4000 horse-power but this was exceeded by 422, the mean indicated horse-power for the three hours being 4422, with a mean of 264 revolutions per minute for the starboard engine and 265.23 for the port engine. The assistant cylinders gave 16.80 indicated horse-power, this power being added to the power developed by the main engines.

The highest number of revolutions per minute, reached several times during the trials, was 269 for the starboard engine and 276 for the port ; the approximate maximum power reached was nearly 4800 indicated horse-power. A mean speed of 20.70 knots was obtained during the three hours' trial. There was rain and wind blowing strongly from the southwest toward the finish of the trial.

THE RE UMBERTO.

[*Journal of the Royal United Service Institution.*]

The Re Umberto, one of the largest of the new battleships for the Italian Navy, went out on the 25th October for the official trials, and the final acceptance of the machinery from the makers, Messrs. Maudslay, Sons & Field, of London. The trials proved of a highly satisfactory character. The contract stipulated for the development of 15,200 I. H. P. natural draught, and 19,500 I. H. P. forced draught, but the government, as hereinafter shown, decided to abandon the forced draught trials. The run was made from Spezia to Genoa and back, a distance of 120 knots, at an average speed of 18.3 knots, the

engines indicating a mean of about 17,000 H. P. with ¾ in. air pressure in the stokeholds. The maximum power during the run was found to be 19,000 H. P., and the maximum speed 18½ knots, which was obtained by only ½ in. air pressure. The machinery worked smoothly in every respect, no water service being used. The boilers gave a plentiful supply of steam without priming or other difficulties. The results were considered so satisfactory from every point of view, both as regards the speed of the vessel and the facility with which the speed could be maintained (the trial being made by the ordinary ship's crew of stokers, and not by picked men), that the commission appointed recommended the Ministry of Marine to accept the machinery without further trials, as it appeared so obvious that the I. H. P. with forced draught would largely exceed the contract power of 19,500. The recommendation was therefore accepted by the Minister of Marine. She is 400 ft. long, has a beam of 76 ft. 9 in., and with a draught of 28 ft. 6 in. she has a displacement of 13,375 tons. Protection is afforded by side armor extending from 3 ft. 3 in. below the water-line to the upper deck; the armor is not, however, carried the whole way round the ship, but at the water line, and for 3 ft. 3 in. above and below, extends for a length of 234 ft. Above this again, up to the upper deck, the armor covers the side for 215 ft.; the thickness of the plating, however, is only 4 in.; at each end of the belt are 3-in. armor bulkheads rising from the armored to the upper deck; there is, in addition, an armored deck with a maximum thickness of 4 in. There are two barbettes, one forward and one aft, protected with 18-in. armor, while the ammunition tubes, conning tower, etc., have 12-in. plating. Her armament consists of four 67-ton, eight 6-in. Q. F., sixteen 4.7-in. Q. F., and thirty-one smaller Q. F. guns, with eight torpedo-tubes. She has a coal stowage of 1200 tons.

RUSSIA.

THE TWELVE APOSTLES.

The Russians, still steadily carrying out the process of strengthening that Black Sea fleet, which, by the provisions of the Treaty of Paris, they have no right to have, now have afloat in those waters a fleet of four battleships, besides many smaller craft and others approaching completion. The latest of those in commission is the Twelve Apostles, a formidable fighting vessel of 8076 tons displacement and 17½ knots speed. Her principal armament consists of four 52-ton breech-loading cannon, mounted in two dome-like turrets, plated with 12-in. armor. In addition, she has four 6-in., eight small quick-firing, and two machine guns. She is protected by an armor belt 14-in. in thickness, and a steel deck averaging 2½ in. thick; six torpedo-tubes complete her means of offense.

SPAIN.

THE INFANTA MARIA TERESA.

The following are the results of trial trips of the Spanish cruiser Infanta Maria Teresa, as announced:

	Natural Draught.	Forced Draught.
Mean speed (knots)	18.5	20.25
Indicated horse-power, starboard	4,686	6,857
Indicated horse-power, port	4,872	6,901
Indicated horse-power, total	9,558	13,758
Revolutions starboard	105	118
Revolutions port	106	118
Vacuum starboard	27½	27½
Vacuum port	27½	28
Steam pressure (lbs.)	145	145
Air pressure (in.)	$\frac{3}{16}$	1

The Infanta Maria Teresa is built entirely of Siemens-Martin steel, is 340 ft. long between perpendiculars, and 364 ft. over all, with a breadth of 65 ft., and a depth of 38 ft., displacing 7000 tons on a mean draught of 21 ft. 6 in. She has the usual ram bow, and carries two masts, each having a military top and signaling yard. The masts and funnels have just enough rake to give her a very smart appearance. For 315 ft. amidships she has an armor belt 5 ft. 6 in. broad, backed by 6-in. teak. The plates, which were supplied by Messrs. Cammell & Co., are 12 in. thick, secured by $3\frac{1}{2}$-in. bolts. She has the usual cellular double bottom, and has eleven transverse water-tight bulkheads, the bunkers being arranged in the usual manner to afford the machinery as much protection as possible. She carries in all twelve boats, including a 60-ft. 17-knot vedette boat.

The ship has in all eight torpedo-tubes, and the principal armament is as follows: Two 28-centimetre guns (one forward and one aft) mounted in barbette turrets, ten 14-centimetre guns, two 7-centimetre guns, eight 57-millimetre Nordenfeldts, two 11-millimetre Nordenfeldts, and eight Hotchkiss.

The propelling engines are of the vertical triple-expansion, surface-condensing, direct-acting type, driving twin-screws, and are designed to develop collectively about 13,506 indicated horse-power with forced draught, the contract speed for which is 20 knots. The dimensions of cylinders are: High pressure, 42 in.; intermediate pressure, 62 in.; and low pressure 92 in., with 46-in. stroke. The cylinders are fitted throughout with Whitworth's fluid compressed steel liners. In both engine and boiler-rooms there is plenty of clear space. The cylinders, cylinder covers, pistons, and steam chest doors are all of cast steel.

Steam is supplied by four double-ended boilers, 16 ft. 3 in. in diameter, and two single-ended boilers, 15 ft. 3 in. long by 10 ft. 6 in. in diameter, and working at a pressure of 150 lbs. per square inch, the test pressure being 250. Following out the usual plan, to provide greater safety, the boilers are placed in two separate compartments, the bunkers being run along each side in the usual way. There are two funnels, 9 ft. in diameter, the height from dead-plate to top of funnel being 69 ft.

CHILI.

LAUNCH OF THE BLANCO ENCALADA.

Recently there was launched from the shipyard of Sir W. G. Armstrong, Mitchell & Co., at Elswick, Newcastle, a new cruiser for the Chilian Republic, named the Blanco Encalada. The vessel is 370 ft. in length; 46 ft. 6 in. in breadth; draught, 18 ft. 6 in.; displacement, 4400 tons; indicated horse-power, 14,500; speed under forced draught, $22\frac{1}{4}$ knots. The armament is heavy, consisting of two 8-in. breech-loading guns, ten 6-in. quick-firing guns, twelve 3-pounder guns, twelve 1-pounder guns; and five torpedo-tubes.

THE WARSHIPS OF THE FIVE GREAT NAVAL POWERS.

The warships belonging to the five naval powers mentioned, in commission, in reserve, and building in the year 1893, are in numbers as follows:

Great Britain.—Has in commission: 24 battleships; 4 coast defense ships, armored; 63 cruisers, armored and unarmored, and 78 other ships, not torpedo-boats. In reserve: 10 battle ships; 16 coast defense ships, armored; 49 cruisers, armored and unarmored, and 50 other ships, not torpedo-boats. Building and completing for sea: 9 battleships; 19 cruisers, armored and unarmored, and 23 other ships, not torpedo-boats.

France.—Has in commission: 19 battleships; 5 coast defense ships, armored; 23 cruisers, armored and unarmored, and 50 other ships, not

torpedo-boats. In reserve: 5 battleships; 3 coast defense ships, armored; 20 cruisers, armored and unarmored, and 62 other ships, not torpedo-boats. Building and completing for sea: 8 battleships; 2 coast defense ships, armored; 19 cruisers, armored and unarmored, and 5 other ships, not torpedo-boats.

RUSSIA.—Has in commission: 5 battleships; 9 cruisers, armored and unarmored; 34 other ships, not torpedo-boats. In reserve: 2 battleships; 9 coast defense ships; 6 cruisers, armored and unarmored; 37 other ships, not torpedo-boats. Building and completing for sea: 8 battleships; 4 coast defense ships; 2 cruisers, armored and unarmored; 4 other ships, not torpedo-boats.

GERMANY.—Has in commission: 11 battleships; 14 cruisers, armored and unarmored; 19 other ships, not torpedo-boats. In reserve: 3 battleships; 6 coast defense ships, armored; 17 cruisers, armored and unarmored; 5 other ships, not torpedo-boats. Building and completing for sea: 7 battleships, 3 cruisers, armored and unarmored, and 1 ship, not a torpedo-boat.

ITALY.—Has in commission: 4 battleships; 8 cruisers, armored and unarmored; 16 other ships, not torpedo-boats. In reserve: 9 battleships; 5 coast defense ships, armored; 5 cruisers, armored and unarmored; 26 other ships, not torpedo-boats. Building and completing for sea: 4 battleships; 13 cruisers, armored and unarmored; 3 other ships, not torpedo-boats.

LISTS OF THE BATTLESHIPS AND FAST ARMORED CRUISERS OF THE ENGLISH AND OF THE FRENCH AND RUSSIAN FLEETS, WITH TONNAGE, APPROXIMATE SPEED, AND ARMAMENTS (OVER 3 IN.).

[*Engineering*].

ENGLISH SHIPS.

Year when Completed	Name of Ship.	Displacement.	Speed. On Trial and Estimated.	Armaments. Muzzle-loading.	Armaments. Breech-loading.	Armaments. Calibres.	Armor at Water Line. Iron (I), Steel (S) or Composite (C).	Armor at Water Line. Thickness. From	Armor at Water Line. Thickness. To
		tons.	knots.	No.	No.	in.		in.	in.
1866	Bellerophon*.....	7,550	Depends upon condition of machinery	10 4 ..	 6	8 6 4	I		6
1868	Hercules*........	8,680	14.4	8 2 4	.. .. ..	10 9 7	I	9	6
1869	Monarch	8,320	14.75	4 2 1	.. .. ..	12 9 7	I	7	6
1870	Iron Duke........	6,010	Depends upon condition of machinery.	10 ..	.. 4	9 5	I	8	6
1870	Invincible	6,010		10 ..	.. 6	9 4	I	8	6
1870	Audacious........	6,010		10 ..	.. 8	9 4	I	8	6
1872	Swiftsure*........	6,910		10 ..	.. 8	9 4	I	8	6
1873	Triumph*........	6,640		10 ..	.. 4	9 5	I	8	6
1871	Sultan*...........	9,290	Under reconstruction.				I	9	6
1873	Devastation......	9,330	13.75	..	4	10	I	12	10
1876	Alexandra........	9,490	14.75	.. 8	4 ..	9.2 10	I	12	6
1877	Téméraire.	8,540	14.25	4 4 ..	 6	12 10 4		11	8
1877	Thunderer.... ...	9,330	13.75	..	4	10	I	12	10
1878	Dreadnought.....	10,820	14.25	4	..	12.5	I	14	11
1881	Neptune*	9,310	14.25	4 2	.. ..	12.5 9	I	12	9
1880	Superb...........	9,170	13.5	16 ..	.. 6	10 4	I	12	7
1880	Inflexible.........	11,880	13.75	4 ..	.. 8	16 4	I	24†	
1885	Ajax.............	8,660	13.25	4 ..	.. 2	12.5 6	C	18†	
1884	Agamemnon	8,660	13.25	4 ..	.. 2	12.5 6	C	18†	

* One propeller only.
† Ships with less than 50 per cent. of water-line armored.

ENGLISH SHIPS, MODERN TYPE.

Year when Completed.	Name of Ship.	Displacement.	Speed. On Trial and Estimated.	Armaments.			Armor at Water Line.		
				Muzzle loading.	Breech-loading.	Calibres.	Iron (I), Steel (S) or Composite (C).	Thickness.	
								From	To
		tons.	knots.	No.	in.	in.		in.	in.
1886	Conqueror........	6,200	15.5	..	2 4	12 6	C	12†	
1887	Hero.	6,200	15.5	..	2 4	12 6	C	12†	
1885	Colossus	9,420	15.5	..	4 5	12 6	C	18†	
1886	Edinburgh........	9,420	15.5	..	4 5	12 6	C	18†	
1886	Collingwood......	9,500	16.5	..	4 6	12 6	C	18†	
1888	Anson	10,600	16.75	..	4 6	13 5 6	C	18†	
1887	Benbow..........	10,600	16.75	..	2 10	16.25 6	C	18†	
1887	Rodney..........	10,300	16.75	..	4 6	13.5 6	C	18†	
1887	Camperdown.....	10,600	16.75	..	4 6	13.5 6	C	18†	
1887	Howe	10,300	16.75	..	4 6	13.5 6	C	18†	
1890	Sans Pareil.......	10,470	16.75	..	2 1 12	16 25 10 6	C	18†	
1890	Nile..............	11,940	16 5	..	4 6	13.5 4.7	C	20	16
1889	Trafalgar.........	11,940	16.5	..	4 6	13.5 4.7	C	20	16
1893	Empress of India..	14,150	17.5	..	4 10	13.5 6	C	18	14
1892	Hood............	14,150	17.5	..	4 10	13.5 6	C	18	14
1893	Ramillies.........	14,150	17.5	..	4 10	13.5 6	C	18	14
1893–4	Repulse..........	14,150	17.5	..	4 10	13.5 6	C	18	14
1893	Resolution........	14,150	17.5	..	4 10	13.5 6	C	18	14
1893–4	Revenge..........	14,150	17.5	..	4 10	13.5 6	C	18	14
1893–4	Royal Oak..	14,150	17.5	..	4 10	13.5 6	C	.8	14
1892	Royal Sovereign..	14,150	17 5	..	4 10	13.5 6	C	18	14
1893	Barfleur..........	10.500	18.5	..	4 10	10 4.7	C	12	
1893	Centurion.........	10,500	18.5	..	4 10	10 4.7	C	12	

† Ships with less than 50 per cent. of water-line armored.

FRENCH AND RUSSIAN (R) SHIPS.

Year when Launched.§	Name of Ship.	Displacement.	Speed. On Trial and Estimated.	Armaments.		Armor at Water Line.		
				Breech-loading.	Calibres.	Iron (I), Steel (S) or Composite (C).	Thickness. From	To
		tons.	knots.	No.	in.		in.	in.
1867	Koniaz Pojarski........R	5,000	Depends upon condition of machinery.	4 2	8 6	I	4½	3½
1868	Océan (wood)............	7,500		4 4 4	10.8 9.45 5.5	I	8	7
1869	Marengo (wood)*.........	7,000		4 4 7	10.8 9.45 5.5	I	8	7
1870	Suffren (wood)*...........	7,600		4 4 6	10.8 9.45 5.5	I	8	7
1872	Peter the Great.........R	9,340		4	12	I	14	8
1872	Friedland*................	8,408		8 8	10.8 5.5	I	9	7
1873	Richelieu (wood).........	8,200		6 5 8	10.8 9.45 5.5	I	8½	7
1875	Colbert (wood)*	8,320		8 2 6	10.8 9.45 5.5	I	8½	7
1876	Trident (wood)*..........	8,060		8 2 6	10.8 9.45 5.5	I	8½	7
1876	Redoutable...............	8,860		8 6	10.8 5.5	I	14	9
1879	Amiral Duperré	10,325	15	4 1 14	13.4 6.5 5.5	I	21½	10
1879	Dévastation..............	9,500	15	4 4 6	13.4 10.8 3.9	I	15	10
1881	Courbet..................	9,500	15	4 4 10	13.4 10.8 5.5	I	15	15
1882	Terrible..................	7,050	14.5	2 4	16.54 3.9	C	20	13
1883	Amiral Baudin............	11,330	15.25	3 4 8	14.57 6.5 3.5	S	21½	14
1883	Indomptable..............	7,070	14.75	2 4	16.54 3.9	C	20	13
1885	Formidable...............	11,260	16	3 4 8	14.57 6.5 5.5	C	22	14
1885	Caïman....................	7,120	14.25	2 4	16.54 3.9	C	20	14
1885	Requin....................	7,060	14.25	2 4	16.54 3.9	C	20	12

* One propeller only.

§ The dates of completion of the French and Russian ships may be taken at from three to four years after launching.

FRENCH AND RUSSIAN (R) SHIPS.—MODERN TYPE.

Year when Launched. §	Name of Ship.	Displacement.	Speed. On Trial and Estimated.	Armaments. Breech-loading.	Armaments. Calibres.	Armor at Water Line. Iron (I), Steel (S) or Composite (C).	Thickness From	Thickness To
		tons	knots	No.	No.		in.	in.
1886	Hoche	10,400	17	2 2 18	13.4 10.8 5.5	C	18	14
1886	(B. S.) Caterina II.......R	10,150	16	6 7	12 6	C	16	
1886	(B. S.) Tchesmé.........R	10,150	16	6 7	12 6	C	16	
1887	(B. S.) Sinope...........R	10,150	16	6 7	12 6	C	16	
1887	Marceau	10,400	16	4 17	13.4 5.5	C	18	14
1887	Neptune	10,400	16	4 17	13.4 5.5	C	18	14
1887	Alexander II.......... R	8,440	16	2 4 8	12 9 6	C	14	6
1888	Nicolas I...............R	8,440	16	2 4	12 9 6	C	14	6
1890	Magenta	10,400	16	4 17	13.4 5.5	C	18	14
1890	(B. S.) Dvenadsat Apostoloff................R	8,100	16.5	4 4	12 9	C	16	
1891	Navarin.................R	9,500	16	4 8	12 6	C	17	
1893	Brennus	10,810	17.5	3 10	13.4 6.5	C	17½	
	ENGLISH SHIPS, BUILDING AND COMPLETING AND ORDERED.							
Commenced								
1893	Renown	12,350	18	4 10	10 6			
Ordered 1893	Magnificent	15,000	18	4 etc.	12			
	Majestic	15,000	18	4 etc.	12			
	ENGLISH ARMORED CRUISERS OF 15 KNOTS AND UPWARDS.							
Completed								
1886	Impérieuse	8,400	17.	4 10	9.2 6	C	10†	
1887	Warspite	8,400	16.75	4 10	9.2 6	C	10†	
1887	Australia	5,600	18.5	2 10	9.2 6	C	10†	
1887	Orlando	5,600	18.5	2 10	9.2 6	C	10†	
1887	Galatea	5,600	18.5	2 10	9.2 6	C	10†	
1887	Narcissus	5,600	18.5	2 10	9.2 6	C	10†	
1887	Undaunted	5,600	18.5	2 10	9.2 6	C	10†	
1888	Aurora	5,600	18.5	2 10	9.2 6	C	10†	
1888	Immortalité	5,600	18.5	2 10	9.2 6	C	10†	
	Powerful	14,000						
	Terrible	14,000						

† Ships with less than 50 per cent. of water-line armored.

§ The dates of completion of the French and Russian ships may be taken at from three to four years after launching.

FRENCH AND RUSSIAN (R) SHIPS.

(BUILDING AND COMPLETING AND ORDERED).

Year. §	NAME OF SHIP.	Displacement.	Speed. On Trial and Estimated.	ARMAMENTS. Breech-loading.	ARMAMENTS. Calibres.	ARMOR AT WATER LINE. Iron (I), Steel (S) or Composite (C).	Thickness From	Thickness To
Commenced about		tons.	knots.	No.	in.		in.	in.
1890	Bouvines	6,650	17	2 4	13.4 3.9	S	18	14
1890	Jemmapes	6,450	17	2 4	13.4 3.9	S	18	14
1890	Valmy	6,450	17	2 4	13.4 3.9	S	18	14
1890	Tréhouart	6,650	17	2 4	13.4 3.9	S	18	14
1891	Jauréguiberry (launched 1893)	11,600	17.5	2 2 8	11.81 10.8 5.5	S	18	
1891	Charles Martel	11,800	17	2 2 8	11.81 10.8 5.5	S	18	
1891	Lazare-Carnot	11,800	17.5	2 2 8	11.81 10 8 5.5	S	18	
1892	Masséna	11,000	17	2 2 8	11.81 10.8 5 5	S	18	14
1893	Bouvet	12,000	17.5	2 2 8 8	11.81 10.8 5.5 3.9	S	15¾	8
Ordered 1893	New ship	12,000	..	4 etc.	11.81			
Ordered 1893	" "	12.000	..	4 etc.	11.81			
Ordered 1893	" "	12,000	..	4 etc	11.81			
Commenced about								
1889	(B. S.) Tri Svyatitelya...R	12,500	16	4 4	12 9	C	16	
	(B. S.) Georgiy Pobiedoscetz ...R	10,280	16	4 4	12 9	C	16	
1891	Petropaulovsk...R	11,000	..	4 8	12 8	C	16	
1891	Poltava...R	11,000	..	4 8	12 8	C	16	
1891	Sevastopol...R	11,000	..	4 8	12 8	C	16	
1889	Sizoi Velikij... R	8,440	16	2 4	12 9	C	16	
1892	(B. S.) New ship...R	10,000						
1892	" " ...R	10,000						

§ The dates of completion of the French and Russian ships may be taken at from three to four years after launching.

ARMORED CRUISERS OF 15 KNOTS AND UPWARDS.

Year. §	NAME OF SHIP.	Displacement.	Speed. On Trial and Estimated.	Armaments. Breech-loading.	Armaments. Calibres.	Armor at Water Line. Iron (I), Steel (S) or Composite (C).	Armor at Water Line. Thickness From	Armor at Water Line. Thickness To
	French.	tons.	knots.	No.	in.		in.	in.
Completed 1892–93	Dupuy de Lôme..........	6,130	20	2 6	7.64 6.5	C	3½	
	Bruix....	4,665	19	2 6	7.64 6.5	C	3½	
	Charner..................	4,665	19	2 6	7.64 6.5	C	3½	
Building	Pothuau..................	5,238	20	2 10	7.64 5.5	C	3⅛	2
	Latouche Tréville.........	4,665	19	2 6	7.64 6.5	C	3½	
	Chanzy....................	4,665	19	2 6	7.64 6.5	C	3½	
	D'Entrecasteau...........	8,000	19	2 8	9.5 6.5			
	New ditto................	8,000	19	2 8	9.5 6.5			
	Russian.							
Completed 1883–4	Vladimir Monomach....R	5,796	17	4 12	8 6	C	7	5
	Dimitri Donskoi........R	5,893	15.5	2 14	8 6	C	7	5
1889	Admiral Nachimoff. ....R	7,782	16.75	8 10	8 6	C	10	
1889	Pamyat Azova..........R	6,000	17.5	2 14	8 6	C	6	4
1893	Gangoot ....R	6,592	16.5	6 6	9 6	C	16†	
	Rurik.... ....R	10,023	18.5	4 16	8 6	C	1	
	New Rurik (larger).....R " " (larger).....R	..	Natural draught	6	4.75			

† Ships with less than 50 per cent. of water-line armored.

§ The dates of completion of the French and Russian ships may be taken at from three to four years after launching.

The numbers of the various classes may be summarized as follows:

Battleships.	England.	France.	Russia.
Earlier types.................	19	17	2
Modern types:			
Built......................	23	5	7
Building..................	3	12	8
		34	17
Total............	45	51	
Fast Armored Cruisers.			
Built	9	3	6
Building..................	2	5	2
	11	8	8

These numbers are exclusive of two powerful armored, so-called, coast defense ships, building by Russia, the Admiral Ortschakoff and the Admiral Senjavin, each of 4000 tons, and carrying two 9-in. guns, which cannot be classified as battleships.

THE LOSS OF H. M. S. VICTORIA.

The following is an extract from the report of Mr. W. H. White, Assistant-Controller and Director of Naval Construction for Great Britain, based upon minutes of proceedings of court-martial appointed to inquire into the cause of the loss of H. M. Ship Victoria. The original report is accompanied by ocular proof of the statements advanced in the form of numerous diagrams. The name of the writer is, however, a sufficient guarantee that his conclusions have not been arrived at except upon good and due deliberation, and though very interesting to look at, the illustrations are omitted here. They may, however, be found with the complete report in "The Engineer," of November 10, 1893. The report abridged is as follows:

From the evidence it is established that before the manœuvre began the ships were proceeding at a speed of 8.8 knots, the two lines being 1200 yards apart.

When the signal to turn inwards sixteen points was hauled down, the helm of the Victoria was put hard to starboard—35 deg.—which corresponded to a tactical diameter of about 600 yards. At the same moment the helm of the Camperdown was put at 28 deg. to port, which corresponded to a tactical diameter estimated at about 800 yards. Had the helm of the Camperdown been put hard to port, the tactical diameter would have been reduced about 20 per cent. The two ships continued to turn under these conditions, until they had each turned through about eight points, and were very nearly end-on to one another. Their distance apart at that instant was estimated at two to two and a-half cables—400 to 500 yards. Both ships must then have acquired practically their full "swing"—or angular velocity—corresponding to the conditions of speed and helm angle above stated. Apart from change of helm or alteration in speed and direction of the engine, the ships would have continued to turn in practically circular arcs from eight points onwards. At or near the eight-points position it was recognized in both ships that a collision was imminent, and steps were taken to avoid it if possible. The port engines of the Victoria and starboard engines of the Camperdown were ordered to be reversed practically at the same moment for the purpose of making the ships turn more quickly. These orders were given only about one minute before the collision took place. The Camperdown's speed at the moment when the starboard engine was reversed and the port engine stopped, must have been about 6¾ knots. In the brief interval—less than a minute—before the collision, this speed could have been but little lessened. Hence it appears that Captain Johnstone's estimate of 6 knots is fairly accurate, and not in excess. This is confirmed by the fact that as the Victoria was using about 25 per cent. greater helm than the Camperdown, her speed on the circular path from eight to twelve points must have been checked more from that on a straight course than was the case in the Camperdown. Moreover, both the Victoria's engines were reversed before the collision, and only one engine in Camperdown. Consequently the Victoria must have been moving more slowly than Camperdown, and yet her speed was estimated at 5 to 6 knots.

All the witnesses agree that the Camperdown struck the Victoria nearly at right angles. The weight of evidence is in favor of the view that the keel-line of Camperdown was about 10 deg. *abaft* the beam of the Victoria, the keel-lines then being at an angle of about 80 deg. This is confirmed by an examination of the paths actually traversed under similar circumstances by similar ships when turning from eight to twelve points. The blow was delivered on the starboard side of the Victoria, about 65 ft. abaft the stem-head, and just before important transverse bulkheads which extended from the keel to the upper deck. Observers agree that this terrific blow delivered on the bow of the Victoria, at a time when she was rapidly turning, caused

the fore-end of that vessel to move about 60 ft. or 70 ft. to port. This bodily movement of the Victoria absorbed some of the energy of impact, and tended to lessen the shock and injury done to the structure.

When the ships collided they were both turning rapidly. Consequently after the bow of the Camperdown was engaged in the side of the Victoria, the sterns swung together to some extent. This fact was noted by several witnesses. Those most competent to form an opinion—particularly Lieutenant Barr, of the Camperdown—state that the movement involved a swinging of the Camperdown relatively to the Victoria through an arc of about 20 deg. It is stated further that the two ships were locked together for about a minute, before the Camperdown backed astern and cleared—which she did at an angle of about 30 deg. abaft the beam of the Victoria. This swinging together of the two ships exaggerated the injuries done to both. For the Camperdown it probably meant the fracture of the stem forging; and it certainly involved very serious damage to the thin side plating on the port bow, which plating was broken through by contact with the side and decks of the Victoria, abaft the breach made by the first impact. On the starboard bow of the Camperdown, where the swinging was practically a freeing one, the damage done was relatively inconsiderable.

The damage to the port bow of Camperdown was chiefly caused by contact with the protective deck of the Victoria. The main part of the bow plating on both sides of the Camperdown, both above and below water, retained its general form. In swinging, therefore, the bow of Camperdown must have crushed in the adjacent plating and structure of the Victoria, and produced a serious enlargement of the breach caused by the first blow. Moreover, it must have destroyed the water-tight connection to the side plating of two important transverse bulkheads situated just abaft the place of collision. Those bulkheads consequently ceased to be water-tight partitions for several feet from the starboard side of the ship.

A careful examination, based upon the known injuries to the plating on the Camperdown's port bow, and the angle abaft the Victoria's beam to which the Camperdown swung while she was locked, gives what must be a very close approximation to the extreme penetration into the side of Victoria effected by the stem of Camperdown. The result of this examination indicates a penetration of about $5\frac{1}{2}$ ft. to 6 ft. for the vertical portion of the stem. The extreme point or "spur" of the ram-bow projects about 7 ft. before this upright portion; and this spur pierced the thin plating below the protective deck, as it was designed to do. Notwithstanding the form of the athwartship section of the Victoria at the place of collision, the spur of the Camperdown was driven about 9 ft. within the side plating, at a depth of about 12 ft. below water. The breach must have extended vertically from the upper deck to a point about 28 ft. below that deck, and 18 ft. below the water-line at which the Victoria floated before collision. The width of the breach varied. At the upper deck it was about 12 ft.; at the original water-line about 11 ft.; then it gradually diminished in general breadth towards the lower termination. The area of the breach below the original water-line must have been 100 to 110 square feet.

A very great depression of the bow was observed within three or four minutes of the collision.

It is proved by the evidence that the water-tight doors, hatches, etc., were in good order and perfectly efficient.

The true cause of failure to close the doors, hatches, etc., in the forward part of the ship is to be found in the very short time before the collision that orders were given to make the attempt. Captain Bourke states that under ordinary conditions of drill, with a trained crew, three minutes were required to close the doors, etc. It is also proved that the order to close doors was given about one minute only before the collision. The men were in their messes or on deck for the most part when this order was given. Using all

possible exertions they could not reach the compartments forward, and especially those below the protective deck, in time to do much, if anything, before the collision had happened, and large quantities of water were entering. In the evidence this is conclusively proved by incidental statements made by the men. Abaft the turret the case was different; as water took some time to find its way into those compartments, the men could work without disturbance or danger, and the doors, etc., were closed and secured.

For convenience it will be desirable to consider separately the two movements which proceeded simultaneously, viz., depression of the bow, and heel to the wounded—starboard—side. It appears that about four minutes after the collision the bow had dipped so much that water was coming through the hawse pipes on to the upper deck. That is to say, the bow had sunk about 10 ft. in four minutes. This change of trim continued, and about two minutes later the water had risen so much on the forecastle that men who had been working there were called away. Immediately before the lurch took place the water was washing into the open turret ports, situated nearly at the middle line 100 ft. from the bow, and at a height of 14 ft. above the original waterline. Captain Moore states that the water was then half-way up the turret wall; and Captain Noel saw the water 2 ft. to 3 ft. deep against the sides of the turret. On investigation it is found that at this moment—accepting Captain Moore's careful observations—the upper deck right forward was 13 ft. under water, having been depressed about 23 ft. below its original position. The forward part of the upper deck was then almost entirely under water, from the bow to the bulkheads forming the forward termination of the upper deck battery. In other words, nearly half the length of the ship was submerged. The after portion of the ship was lifted considerably above its normal position, and the upper blades of the port screw were showing above water to a large extent. The normal position of the tips of the blades was 11 ft. below water. This emergence of the screw was partly due to the heel, but chiefly to change of trim.

Simultaneously with this extraordinary change of trim by the bow, the Victoria was heeling to starboard. All the witnesses on board that ship agree that the motion was gradual and steady until the lurch took place. Their conclusion is supported by witnesses from other ships, and by the fact that nine or ten minutes were occupied in reaching a heel of 18 degrees or 20 degrees from the vertical. There is practical agreement that this was about the heel to starboard at the moment when the lurch took place. Captain Moore, who was taking note of the Victoria at that time, confirms this estimate, and adds some most important information. He saw the water half way up the turret wall, and consequently it must have been flowing through the open ports into the turret, from which it could pass into the redoubt, surrounding the turret-base, and thence could find access to certain spaces below. Further, he noted that the armor-door in the oblique bulkhead at the forward end of the upper deck battery was partly under water. It has been given in evidence that this door was never closed. Consequently water was at the same time passing into the battery, and accumulating on the starboard side. Captain Moore remarked also that the two foremost 6-in. gun ports on the starboard broadside were then just awash. These ports, according to the evidence, were not closed, and therefore when they became "awash" large quantities of water could enter rapidly. In these circumstances it is obvious that a sudden increase of heel was inevitable; and the ship had sustained such a loss of stability from the submergence of her bow and the rise of her stern that she could not recover herself, and eventually capsized.

Up to the time when the ships had turned eight points—or about one minute before the collision—no orders were given to close the water-tight doors, etc., then open. It was "make and mend" afternoon, and the men were in their messes.

Taking the facts established by the evidence, and recorded in Table I., an inquiry has been made into the effect which flooding the compartments therein enumerated should have had upon the trim and transverse inclination of the Victoria. This inquiry has necessitated the performance of certain calculations in the Constructive Department of the Admiralty, those calculations being based upon well-known principles which are universally applied in estimates of the buoyancy and stability of ships. The following is a summary of results: (1) The flooded compartments, nineteen in number, had a capacity which involved a total "loss of buoyancy" (up to the original water-line) of 1110 tons; of this amount less than 110 tons were in compartments above the protective deck, and about 1000 tons in the spaces below that deck. (2) This loss of buoyancy in compartments so far forward produced a "moment to change trim" of about 140,000 foot-tons. Of this total amount the 110 tons above the protective deck account for only 15,000 foot-tons—the balance, nine-tenths of the whole, being due to the water below that deck. The moment due to the 110 tons above the protective deck corresponds to a change of trim of 3 ft. only. The additional moment due to the 1000 tons below the protective deck brings up the change of trim to the enormous amount of 29 ft. Allowing, as is done only for compartments enumerated in Table I., the calculation shows the depression of the bow to be about 21 ft., and rise of stern 8 ft., as compared with their positions before the collision took place. Such a change of trim, however, necessarily flooded also the compartments named in Table III. Consequently, the final depression of the bow, by calculation, fully equals that which was observed by several witnesses as having been reached before the lurch began, and which is estimated from their evidence at 23 ft. (3) As the bow sank, water entered the upper part of the vessel through the breach, and filled all the space between the upper and main decks back to the oblique water-tight bulkheads situated just abaft the turret. Certain small store-rooms were also filled from above as the bow sank, but this circumstance was relatively unimportant. (4) Neglecting water which may have entered through the turret ports, when the Victoria had reached the position occupied before the lurch, there must have been about 2200 tons of water in the interior of the ship, before the fore boiler-room and below the upper deck. (5) The case was aggravated by the entry of water in the turret, redoubt, and spaces below. (6) As explained above, the sudden entry of water into the 6-in. gun battery above the upper deck through the open ports and door, caused the final lurch which led to the capsizing and foundering of the vessel. (7) Had the ports in battery and turret, and the armor door been closed, and water excluded from both battery and turret, the Victoria would not have capsized, and would have remained afloat for a much longer time, even if eventually she had foundered.

It is not possible to state absolutely that the Victoria, with turret and battery closed, could have been kept afloat permanently under the actual circumstances of the collision. There are so many compartments (see Table II.) into which water may have found its way eventually, through doors and hatches respecting which there is no direct evidence whether they were closed or not. But this would have involved still further change of trim by the head, and her capsizing would have been improbable even if she had eventually foundered. Allusion has been made above to the great reduction in stability necessarily produced by such an extreme submergence of the bow and accompanying rise of stern as were observed in the Victoria before the lurch began. This fact is well known to naval architects, and can be readily understood apart from exact calculations.

The power of a ship to resist inclination from any position in which she floats at rest, depends greatly upon the moment of inertia of her buoyant water-line section—or plane of flotation. Any causes which reduce this moment of inertia lessen the stability.

TABLE I.

Compartments Shown by the Evidence to have been Thrown Open to the Sea, Either by Direct Damage or through Open Doors, Hatches, etc.

Name of compartment.	Loss of buoyancy, in tons.	Distance in feet from: Middle of length of ship.	Distance in feet from: Middle line of ship, starboard side.
Above protective deck:			
Small compartment leading to capstan flat,	8½	132	..
Fresh water tank-room..................	25	122	..
*Cable lockers........................	34	109	..
*No. 1 coal bunker, 18 to 23, starboard side,	8	108	18
*Coal bunkers, Nos. 3 and 5...............	33	87	14
Total above protective deck	108½		
Platforms to protective deck:			
Compartment fore end of capstan room...	18	130	..
*Capstan engine-room	80	116	..
*Carpenter's store, frame 14 to 22.........	50	114	13
*Torpedo flat, 22 to 27....................	200	96	2 port side
Submerged torpedo room.................	260	78	..
Spaces between 35, the ring bulkhead, and 43,	75	62	..
hold below platforms:			
*Water-tight compartment starboard side, 12 to 22............................	108	117	6
*Water-tight compartment below, from 12 to 22................................	20	117	4
*Water-tight compartment, 22 to 31, starboard side	50	88	18½
*Water-tight compartment below provision-room, etc., 22 to 31....................	60	88	..
*Torpedo magazine, or gun-cotton magazine,	33½	98	8
No. 7 coal bunker and chute..............	47	44	25
Total below protective deck........	1001½		
Grand total........................	1110		

NOTES.—(1) The compartments marked with an asterisk are those which it is considered must have been flooded in consequence of the collision, even had doors, hatches, etc., been closed prior thereto. (2) For compartments above the protective deck the loss of buoyancy—108½ tons—is estimated up to the water-line at which the Victoria floated before the collision. This loss will be seen to be about 10 per cent. of the total loss. Had no loss taken place below the protective deck, the flooding of compartments named above that deck would have produced a change of trim of only 3 ft., and a heel of less than 3 deg. When the compartments below the protective deck were also flooded, the change of trim became 29 ft., and the heel to starboard 18 to 20 deg.

TABLE II.

Compartments Shown by the Evidence to have been Probably or Possibly Filled through Doors, Hatches, etc.

Name of compartment.	Loss of buoyancy, in tons.	Distance in feet from — Middle of length of ship.	Distance in feet from — Middle line of ship, starboard side.
Above protective lower deck :			
Air-compressing room, port side..........	22	39	16 port side
Sail room, chest room, torpedo room, with turret support, 35 to 52..................	300	54	1½
Platforms to protective or lower deck :			
Compartments between bulkheads, 43 and 53, and turret support. Space for empty powder cases..........................	200	47	..
Hold below platforms :			
Water-tight compartment, port side, 12 to 22,	108	117	6 port side
Port ejector tank	35	70	19 " "
Total tons......................	665		

NOTE.—All the compartments mentioned in Table II., except those below platforms, are within the limits of the armor belt.

TABLE III.

Compartments Ultimately Filled through Riding Bitts by the Depression of the Bow.

Name of compartment.	Loss of buoyancy, in tons.	Distance in feet from — Middle of length of ship.	Distance in feet from — Middle line of ship, starboard side.
Above protective deck :			
Boatswain's and carpenter's stores, 7 to 14,	100	138	..

CONCLUSIONS.

Summing up the results of the careful inquiry which has been made into the evidence given before the court-martial, of which details appear in the foregoing remarks, the following broad conclusions are reached: (1) That the interval of time which elapsed between the instant when orders were given to close water-tight doors and hatchways, and the instant of actual collision—viz., about one minute—was necessarily inadequate for the complete fulfilment of that intention, more especially in compartments forward below the protective deck, and near to the place of collision. (2) That, although every endeavor was made to close the water-tight doors subsequently to the collision, the doors and hatchways which are proved to have remained open, permitted water to pass into compartments adjacent to those breached ; and consequently greatly increased the loss of buoyancy, the depression of the bow, and the diminution of transverse stability. (3) That, so far as can be judged, had all doors, hatchways, etc., been closed prior to the collision, the Victoria would have continued to retain ample buoyancy and stability, and would not have ceased to be under control. (4) That, under the actual circumstances of the collision, and with the doors remaining open which have been enumerated above, it was inevitable that the vessel should have attained the position described by the various witnesses as reached before the lurch began ; with her bow buried about 13 ft. below water, and with a heel to starboard of about 18 deg. to 20 deg. (5) That,

even when so seriously injured and brought to such a critical condition, had the ports in the turret and upper-deck battery been closed, the armor door secured, and water excluded from turret and battery, the Victoria would not have capsized. It is possible that she may have eventually foundered in consequence of the gradual passage of water into compartments respecting which the evidence leaves us in doubt. (6) That, under the serious circumstances of this collision or of any similar accident which may occur, the safety of a ship and her continued flotation demand that provision should be made for closing gun ports and openings in upper works, through which water may pass into the interior of the ship, if the flooding of compartments produces great change of trim or serious heeling. If such precautions are not taken the virtual height of freeboard is reduced to the height of the sills of ports and doors, and the presence of the superstructures when water is not excluded from them, does not assist either buoyancy or stability to a sensible extent.

BOOK NOTICES.

Descriptive Catalogue of War Material, Manufactured by the Hotchkiss Ordnance Company, Limited.

The Hotchkiss Ordnance Company have issued a handsome descriptive catalogue of the war material manufactured by them, neatly bound in a flexible cover.

It is pleasing to look at the illustrations, which are numerous well-selected photographs. These are accompanied by a brief description, sufficient in each case to give a clear idea of the working of the parts illustrated. Among the items of special interest to naval officers are the changes in the breech mechanism from flat main and sear springs to spiral springs. In view of the fact that the flat main spring of the Hotchkiss old model is thoroughly reliable and will even fire a cartridge about every other time that the hammer falls with the drill hook shipped (and is very favorably placed for shifting if injured), and that many guns fitted with spiral main springs will not do better than this latter under the most favorable circumstances (requiring moreover a jerk of the lockstring, which is objectionable on account of the irregularity of the firing interval), the benefit to be gained by the change may be regarded as doubtful.

The differences between the old model and the new in detail are as follows :

Detail.	Old standard model.	1893 model.
Firing point......	Made with rear-projecting spring ears, which clasp the end of the hammer.	Made with a spring-split shank which seats in the head of the hammer.
Main spring......	A double-branched flat spring whose ends are caught on opposite sides of the hammer axle.	A spiral spring which acts on a lug projecting from the hammer axle.
Sear Spring......	Flat......................	Spiral.
Extractor.........	Nib and body in a single piece.	Nib separate from the body and having a slight spring movement to aid extraction and resist shocks.
Stop bolt.........	Screws into its seat.........	Held in its seat and also held, when partially withdrawn, by a spring.
Trigger..........	Of the ordinary bent-lever form, one end resting on the end of the sear.	None at all, the sear being actuated direct by a firing lanyard.
Cocking toes.....	Arranged to cock by downward pressure.	Arranged to cock by pressure to the rear.

Detail.	Old standard model.	1893 model.
Pistol grip.......	Ordinary type, secured to the right lower side of the breech.	None at all.
Rear sight........	Screwed permanently to face of breech.	Clamped to face of breech, permitting instantaneous removal and clamping.
Crank handle.....	Permanently attached to crank-shaft by feather and keep-screw.	Attached to crank shaft by square head and snap-spring. Removable and interchangeable.

Among other matter is a description of 3-inch 10-pdr. gun to be used for naval landing purposes.

"This gun is specially designed for naval-landing service and is not fitted for either ship or boat use. Its object is to give a thoroughly effective shrapnel fire, although its weight is within the limit of hand draught. The calibre of the gun is three inches, which is almost the smallest permissible for the construction of effective shrapnel. The breech-block is of the horizontal sliding pattern, having no firing mechanism, but using the primerless-cartridge case and friction primer. The gun is not high-powered, its length of bore being twenty-one calibres. The carriage is fitted with a trail wheel to permit manœuvring without the limber, and carries two boxes of ammunition. The limber is fitted to carry four boxes of ammunition, making a total of forty-eight rounds carried. In every respect the mechanism, equipment, and accessories of this gun are reduced to the fewest possible pieces.

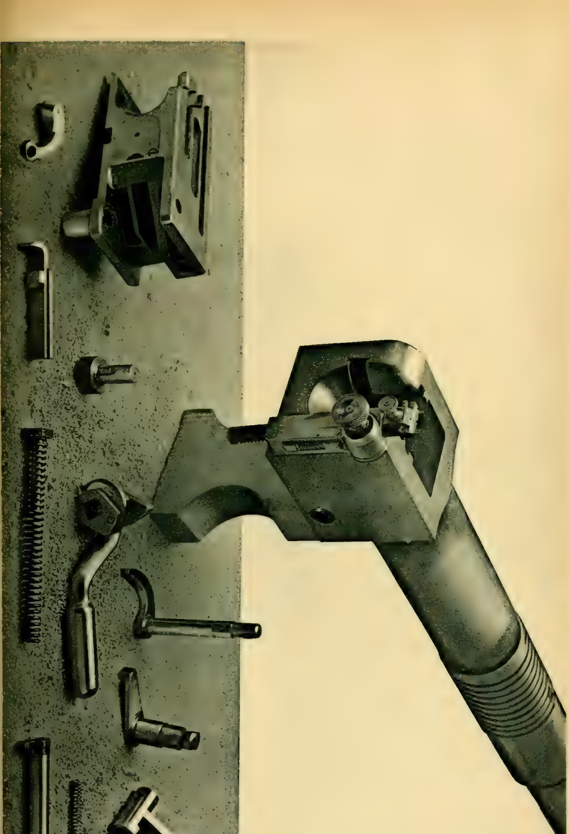
Weight of gun............................	352 lbs.
Weight of carriage........................	550 lbs.
Weight of limber..........................	847 lbs.
Weight of cartridge complete..............	12½ lbs.
Weight of projectile......................	10 lbs.
Initial velocity..........................	1,197 feet."

Not the least interesting object in the book is the Hotchkiss 1-pdr. R. F. G. with recoil mount on a shifting steel stand.

The illustration is unaccompanied by any description, but the use of such a shifting gun is apparent in the increase of fire that could be brought to bear from any quarter of a ship. A pattern for shifting to ordinary rails, or to suitably constructed stanchions or stanchion-sockets would be another step in the same direction. The stand might be placed on a flat-topped rail, or better, it might be shortened somewhat, the gun captain standing on a suitable shelf or transom inside the rail.

A brief description of the Howell torpedo and the tubes for discharging it are included in the catalogue. The normal size of the torpedo is somewhat smaller than that of the smallest type of Whitehead.

Diameter of torpedo......................	14.2 inches.
Extreme length...........................	11 feet.
Launching weight.........................	505 lbs.
Weight of explosive carried..............	100 lbs.
Speed for 400 yards......................	25 knots.
Effective range..........................	750 yards.



Numerous other descriptions and illustrations are included, many of them appertaining more particularly to the Army than the Navy. With those left unmentioned which pertain to the Navy, naval officers generally are more or less familiar.

The following are the contents given in some detail: Nomenclature of Hotchkiss standard war material, comprising: Guns of sizes varying from 37-mm. calibre and 1-pound projectiles to 155-mm. and 100-pound projectiles; with lengths of bore varying from 20 calibres (revolving cannon) to 50 calibres (6-pdr. H. R. F. using smokeless powder). Mounts and carriages, elastic recoil and hydraulic recoil. Aluminum and brass cartridge cases, with and without primers. Black, brown and (French) smokeless powder, and various fuses. Various sights, including Grenfell electric night-sights; and finally, Berthier-Dandeteau magazine rifle, Howell automobile torpedoes, and centre-pivot, muzzle-pivot and fixed torpedo launching gears. Description of Hotchkiss guns, namely: Light 1-pounder as a mountain gun; heavy 1-pounder as a landing gun; 10-pounder naval landing gun; 3-inch field gun (too heavy for hand draught). Ammunition: Steel shells, shrapnel case-shot, common shell. Special accessories and equipments. Howell automobile torpedo. Centre-pivot launching tube.

PRESENT DEVELOPMENT OF HEAVY ORDNANCE IN THE UNITED STATES, BY W. H. JAQUES, ORDNANCE ENGINEER.

This is in pamphlet form, and is reprinted from the *Journal of the Franklin Institute*, having been delivered as a lecture Jan. 6, 1893. The lecturer keeps within a period of ten years, stating that within that time there has been no radical change in gun construction with the exception of decrease in the number of parts, from the recommendations of the Gun Foundry Board, which were confirmed by the Senate Ordnance Committees. In regard to the new smokeless powders, he says, perhaps the most prominent is cordite. He calls attention to the fact that in the United States all gun steel is made by the open-hearth process, though the practice of gun makers is not uniform, Krupp using the crucible process exclusively, and Russia largely. He then goes into the construction of guns with some detail.

The following is extracted from the pamphlet: I desire to especially emphasize the causes of the mishaps to the British 110½-ton guns, because their failure does not convey to my mind any reflection upon the usefulness of such large calibres, for it is quite as simple for the steel works I have just named to construct a sound 110-ton gun as it is for smaller establishments to make a one-pounder; and there can be no doubt that the more powerful the guns of a battleship are the more formidable an enemy she will be.

I deem the failures mechanical only, and if the guns are constructed in a manner equal to many of the modern marine engines that have been built in Great Britain, they will be equally efficient and serviceable.

The efficient service of these guns must not be compared directly with the number of rounds that can be fired from smaller calibres, and the weight of metal thus employed, but from the effective amount of destructive work that can be got out of them, particularly their power to demolish the hard armor of chilled iron and case-hardened steel now so successfully manufactured.

The tendency to substitute for the larger armament an increased number of guns of reduced calibre, notably of the rapid-fire class, will no doubt soon meet with a reaction, because of the loss of that powerful element of destruction, the shattering power so necessary in combat with heavily armored ships. A mixed battery of large and small guns is no doubt the most useful compromise, for what is a ship to-day other than a compromise—in fact, a combination of compromises?

BIBLIOGRAPHIC NOTES.

AMERICAN.

AMERICAN ENGINEER AND RAILROAD JOURNAL.

Volume LXVII., No. 9, September, 1893. The Steering of Balloons. United States Cruiser Minneapolis. Progress in Flying Machines. General Marine Notes: The Simplex and the Huge Torpedo; The New English Cruiser Bonaventure; New Screw Pitch Gauge; 12-in. Breech-Loading Rifle Mortars.

No. 10, October. Editorial Notes: Invisible Torpedo-Boat; Oriolle Process. General Marine Notes: Trial Trip of the Columbia; Two New English Battleships; Oil Distributing Sea Anchor; Regularity of the Turning of Steam Vessels; Two British Cruisers; Battleships of the French Navy; New French Cruiser; Tail Shaft Preserver. Notes and News: A High Smoke Stack; The Trajectory of a Big Gun (range, 65,616 feet; angle of elevation, 44°; weight of projectile, 474 lbs.; weight of charge, 253 lbs.; initial velocity, 2099 feet); The Gordon Disappearing Carriage; Electric Feeder for the Gatling Gun; A New Smokeless Powder; Thirteen-Inch Gun for the United States Navy; Automatic Block Signaling by the Use of Incandescent Lamps; Test of Holtzer Projectiles at Sandy Hook; The Most Suitable Colors for Signal Post and Semaphore Arms; A New Method of Casting Steel Ingots. Brown Wire-Wound Gun. The Steering of Balloons. The Multitubular Boiler. Progress in Flying Machines. Steam Steering Gear. Armor Trials at Indian Head. Asbestos Pipe Covering Materials.

No. 11, November. Editorial Notes: Coaling Steamers at Sea; Submarine Navigation. Notes and News: A New Explosive; A Steam Artillery Wagon; Tube Plate Boring Tool; Rifle Trenching Tool; The Phonograph as a Cure for Deafness; The Hydrophone. (The principal object of this ingenious device is to give warning to a port or fleet, of the approach of a torpedo-boat even if submerged.) Notes: Steel Crank-Shaft; Large Ship Plates; The Polyphemus; Scrap-Iron Chain Cables; Aluminium Boats; Blowing up of Derelicts; A New Victoria; Ferrules for Marine Boilers; Submarine Sentries; Coaling at Sea; The Condition of the Chicago; Lengthening a Steamship; The Naval Armaments of Europe.

Trial of Schneiders's Nickel Steel Armor for Russia. Progress in Flying Machines. Care of Marine Boilers. Schnebelite—A New Explosive.

In schnebelite, chlorate of potash is mixed with pure cellulose or woody fibre, such as is used for the manufacture of gun-cotton or Schultze powder.

Novel Triple-Expansion Engine.

No. 12, December. Editorial Notes : The Columbia ; The El Cid. Notes and News: Test of Rapid-Fire Guns; The Gifford Gun; Coaling Vessels at Sea ; A Cheap Condenser for Exhaust Steam. Progress in Flying Machines. Index to Vol. LXVII. Evolution of the Ocean Greyhound, by Charles Cramp. General Marine Notes : A Ship Canal Project ; The French Warship Jurequibberrer; The Telephone for Diving Purposes; Electric Lights in Shore Defenses ; Test of Defense Nets ; A Powerful Electric Light House ; Copper Plating Ship's Bottoms ; Battleship Oregon ; Electric Lighting of the Bosphorus ; Ship on Rollers ; Bids for War Vessels ; Double Gun Carriage ; The Most Suitable Coal for Use on Warships ; Trial of the Columbia ; Spanish Cruiser Infanta Maria Teresa. Notes on Long Guns. See's Hydro-Pneumatic Ash Ejector.

CASSIER'S MAGAZINE.

Volume V., No. 25, November, 1893. A New Incandescent Arc Light. Blowing Engines. Compressed Air *vs.* Hydraulic Power Transmission. Technical Schools of America. Rope Power Transmission.

No. 16, December. Fast Ocean Steamships. Some Oil Steam Engines. A Few Facts About Electrical Fire Hazards. The Life and Inventions of Edison.

COLLIERY ENGINEER.

Volume XIII., No. 10, May, 1893. The Coal Fields of Canada. The Coal Fields of New South Wales.

No. 11, June. Losses in Transmission of Steam.

No. 12, July. Phosphor Bronze. Anthracite Coal Statistics.

Volume XIV., No. 1, August. The Coal Fields of Canada. Anthracite in Virginia.

No. 2, September. New Fire Alarm. Anthracite Coal Statistics.

No. 3, October. The Coal Fields of Canada. Anthracite Coal Statistics.

No. 4, November. The Cumberland Coal Fields. The Coal Fields of Canada. Anthracite Coal Statistics.

No. 5, DECEMBER. The Coal Fields of Canada. Anthracite Coal Statistics.

ENGINEER (NEW YORK).

VOLUME XXVI., No. 2, JULY 22, 1893. An Extraordinary Armor Plate and Shell Test.

No. 4, AUGUST 19. Inclined Armor.

No. 6, SEPTEMBER 16. The El Cid.

No. 7, SEPTEMBER 30. Disappearing Gun Carriages.

No. 11, NOVEMBER 25. The Columbia.

No. 12, DECEMBER 9. The Machias.

ELECTRICAL REVIEW.

VOLUME XXIII., No. 8, OCTOBER 14, 1893. Search-Lights and Torpedo-Boats.

During the past summer experiments have been made in the harbor at Newport, R. I., to determine upon measures to be employed by torpedo-boats to escape detection with search-lights. The Cushing has been the boat in use, and much progress has been made. The torpedo-boat at no time used both her boilers in steaming about, and, consequently, did not run as fast as she might. She was tried painted in several colors, but was discovered until a dull green hue was used. Then she ran into the harbor before the powerful search-lights of the cruiser San Francisco and monitor Miantonomoh, as well as the big light at the torpedo station, could detect her. She got within a few feet of each of the war vessels, and in a fine position to do great damage with her torpedoes. One night last week the Cushing entered the harbor, and although both vessels were looking for her, she passed completely around the island, on which is the torpedo station, twice without being detected. These experiments are said to be more successful than any carried on in the same line by any nation. The green appears to be the proper color for torpedo-boats. In the glare of the search-light it is quite like water. At times it resembles the moss-grown rocks.

No. 9, OCTOBER 21. The Electric Capstan.

ENGINEERING MAGAZINE.

VOLUME VI., No. 2, NOVEMBER, 1893. The United States Navy of 1893, by W. H. Jaques, Ordnance Engineer.

A striking article with excellent photographs of practically every ship in the new Navy of the United States. The following is an extract:

"We hear the cry on all sides that no one will disturb us, that even the strongest European powers fear our marvelous resources. These resources will no doubt eventually secure victory, but at what a cost! Meanwhile, increased wealth and consequent luxury, indiscriminate immigration, chronic dissensions in the South American and isthmian States, exclusion laws, and other causes are surely leading us into the midst of dangers that require the insurance of naval preparation, which should be all the more

easy to secure, bringing as it will employment for native labor at a period when a labor crisis is imminent. It is not new to call this preparation an insurance, but I fear very few of either our legislators or our tax-payers realize how low a rate of taxation it requires. It is not one-fourth of what we pay for the insurance on our homes or our lives, and yet the losses of life and property that a war resulting from an absence of adequate insurance of this character would cause are almost incalculable.

"Of those who advocate but one type of warship, the cruiser, I would ask, would you reform the army by abolishing everything but the cavalry? Heavy artillery and coast fortifications alone cannot protect the country any more than battleships. Just as the various lines and types of arms are requisite for the most efficient army, so are a variety of ships needed in the navy, if our personnel are to be victors in the struggles that will surely come for the vast wealth we are accumulating in the United States.

"The struggle to put more in a ship than she can usefully carry still continues, and doubtless the next move will be to individualize ships and design, construct, and fit them for one or more special purposes. While we are all the time increasing the power, variety, and rapidity of fire of our armaments, we seem to have lost sight of their ammunition supply. This last is the most difficult problem of the period. We shall probably have to resort to ammunition supply ships in the manner that coaling vessels accompany blockading squadrons.

The difficulty of coaling ships even in the best weather and under fair conditions while engaged in manœuvres warns us of the necessity of having abundant and large chutes conveniently placed for the reception of fuel, for it will probably be a long time before even liquid fuel will be generally used and much longer before power is generated from the element in which the ship floats.

"In connection with the question of coaling ships, there is the more vital one, the source of coal-supply for our warships. The possession of suitable coaling-stations has been recommended by many administrations, urged by many secretaries, begged for by naval officers and by citizens whose interests in foreign territory may require protection, but never more forcibly or comprehensively than by Secretary Chandler, in 1883, when the number of our coaling-stations, meagre as it was, was in excess of that of a later period."

ENGINEERING-MECHANICS.

No. 260, August, 1893. Armor Tests at Indian Head. French Naval Estimates.

No. 261, September. French Experiments with the Sims-Edison Electric Torpedo. The Minneapolis.

No. 262, October. Magnolia Liners for Propeller-Shafts. Sir Nathaniel Barnaby on the Best Warship of the Future.

No. 263, November. The Germans to Launch Torpedoes from Swinging Turrets.

No. 264, December. The Test of a Seventeen-Inch Curved Plate at Indian Head. A French Hydraulic Forging Press. The Columbia.

ENGINEERING NEWS AND AMERICAN RAILWAY JOURNAL.

VOLUME XXX., No. 36, SEPTEMBER 14, 1893. News: Trial of Holtzer Projectiles; Tornadoes.

No. 37, SEPTEMBER 14. The New U. S. Cruiser Columbia.

No. 38, SEPTEMBER 21. News: Submarine Torpedo-Boats for the United States; Record of the New U. S. Gunboat Castine; The New Magazine Rifle Selected for the United States Navy; Rules Regulating Speed Trials of U. S. Vessels; A New Form of Boiler.

No. 39. SEPTEMBER 28. News: Manholes (illustrated), by A. B. Willits, U. S. N.

No. 40, OCTOBER 5. News: The Holland Submarine Boat.

No. 41, OCTOBER 12. News: Holtzer Armor-Piercing Projectiles at Sandy Hook.

No. 43, OCTOBER 26. News: Difficulties in Working Harvey Armor Plates.

No. 44, NOVEMBER 2. News: The United States Battleship Oregon.

No. 45, NOVEMBER 9. News: The Detroit, Montgomery and Marblehead, three of the newest United States Cruisers, have been found to be dangerously top-heavy, according to press reports.

No. 46, NOVEMBER 16. An Armor-Piercing Mortar Shell. Preliminary Trial of the U. S. Cruiser Columbia.

No. 47, NOVEMBER 23. Production of Heavy Steel Forgings in the United States, by R. W. Davenport. Trial of the Columbia.

No. 48, NOVEMBER 30. Machinery for the New Vessels of the United States. Triple-Screws for Warships.

No. 49, DECEMBER 7. The Effect of Hardening on the Ultimate Strength of Steel (illustrated). Note: Total Cost of the Ships of the New U. S. Navy.

No. 50, DECEMBER 14. A Fire at the Navy Yard at Norfolk, Va.

No. 51, DECEMBER 21. Application of Photography to Surveying.

GENERAL INFORMATION SERIES. OFFICE OF NAVAL INTELLIGENCE.

XII. The International Columbian Naval Rendezvous and Review of 1893.

Organization of U. S. Naval Review fleet, organization of combined fleet, the navies represented, act authorizing the Secretary of the Navy to define and establish suitable anchorage-grounds in Hampton Roads and New York Harbor and to make such rules and regulations as may be necessary

in regard to the movement of all vessels therein. Then follows a comprehensive programme for the naval review. The detailed description of this novel method of celebration will undoubtedly be of great service on future occasions of the same kind.

Naval Manœuvres of 1892. Notes on Ships and Torpedo-Boats. Notes on Ordnance. Notes on Small-Arms. Some Standard Books on Professional Subjects.

HALLIGAN'S ILLUSTRATED WORLD'S FAIR.

PART 29. Ordnance and Armor and Other War Material, by W. H. Jaques.

So-called smokeless powders are replacing brown and cocoa types, and many objections to the former appear to have been removed, Captain Noble's test of the qualities and capabilities of the explosive cordite (due to the researches of Sir Frederick Abel and Professor Dewar) having convinced him that "so far as the experiments I have made are concerned, it has developed no characteristic that would prevent its use in large guns, while its smokelessness and its capability of developing, with the same pressure, energies enormously in excess of those which can be obtained with ordinary powder, present advantages which it would be difficult to overrate."

The Whitehead automobile torpedoes, although still somewhat erratic, have reached an average speed of 29½ knots for 850 yards in the 18-inch type, carrying an explosive charge of 198 pounds. The Howell, while more accurate, has not yet attained so great a speed and range, but it is no doubt the more efficient.

Submarine artillery is still receiving much attention, and excellent results have lately been obtained with the Ericsson-Jaques gun and Lässoe projectiles.

Holland and Baker are still struggling with the submarine boat question. Baker's boat is already a familiar object at Chicago.

With projectiles great success has been obtained, but the Holtzer still retains its lead, although the Firminy-Firth-Carpenter and Wheeler-Sterling claim an equal record. J. H. G.

IRON AGE.

VOLUME LII., SEPTEMBER 7, 1893. History and Modern Development of the Art of Interchangeable Construction in Mechanism, II. Smokeless Powders. The Form of Propellers.

SEPTEMBER 21. The De Laval Steam Turbine. Test of Holtzer Projectiles. The New Navy Rifle. H. S. K.

OCTOBER 12. Copper Coating the Hulls of Vessels by Means of Electricity. Fuel Oil System at the Fair.

NOVEMBER 2. Speed Premium for War Vessels.

NOVEMBER 9. Modern Fixed Ammunition. H. W. J.

NOVEMBER 16. Naval Rapid-Fire Guns. Four-Valve Tandem Compound Engine. Multiple Expansion Engine. Sheet Mill

Progress. The Mercantile Cruisers of Foreign Powers. Introducing Feed Water into Boilers. An 1893 Bessemer Steel Works. Mason Vacuum Regulating Valve.

NOVEMBER 23. A Yacht Engine of New Design. Heavy Steel Forgings, their Production in the United States, by Russell W. Davenport, Bethlehem, Pa. Inaugural Session of the Society of Naval Architects and Marine Engineers.

The first paper presented was by Charles H. Cramp, President of the Wm. Cramp & Sons Ship and Engine Building Company, on "The Evolution of the Atlantic Greyhound."

"Coal Bunkers and Coaling Ship" was the title of a paper by Lieutenant A. P. Niblack, U. S. N., who presented an array of facts showing that the vessels of the Navy could not be coaled rapidly because of the disposition of bunkers and lack of adequate facilities. The following table shows the capacity of the bunkers of some of the ships of the Navy and the time required to fill and trim them:

	Total coal capacity. Tons.	Time required to fill bunkers. Hours.
Atlanta	490	33
Chicago	824	28
Charleston	758	26
Yorktown	380	24
Baltimore	1145	60
San Francisco	628	33
Newark	800	28

As a remedy the author proposed that in cruising ships the bunkers below the protective deck be extended the breadth of the ship, but be divided in two by a fore and aft bulkhead amidships. A pair of bunkers, starboard and port, would thus take up all the space vertically between the protective deck and the inner bottom, and, longitudinally, between the athwartship water-tight bulkheads. It is proposed that one pair be forward of the fire-room and another between the engine and fire-rooms; or, in case there are two fire-rooms, as is usual, and it is desired to add a third pair of bunkers, then between the two fire-rooms. From their large size they would admit of rapid coaling, and from their position would be a great protection from raking fire either forward or aft. The paper then described and illustrated the appliances necessary for handling the coal.

A most valuable paper, profusely illustrated, on "Steel Ships of the United States Navy" was prepared by Theodore D. Wilson, ex-Chief Constructor, U. S. N. He first described the principal features of the steel ships of the Navy whose construction had been undertaken since 1883, and pointed out the differences and the reasons for the changes. Since the above date 43 vessels, of a total displacement of 180,478 tons, and two torpedo-boats have been added to or are being completed for the naval service.

The Columbia.

A description of her boilers and engines.

DECEMBER 7. Notes on the Machinery of the New Vessels of the U. S. Navy, by Geo. W. Melville, Engineer-in-Chief U. S. N.

Work in Hot Pressed Steel. Steel Plate Rolling in Great Britain. The Coxe Furnace. The Schutte Balanced Steam Valve. American Society of Mechanical Engineers.

Their annual convention.

DECEMBER 14. New Boiler Makers' Tools. Recent Progress in the Manufacture of Steel Castings. The Brown Automatic Fire-Alarm System. The Schutte Balanced Check Valve. American Society of Mechanical Engineers.

Many valuable papers were read before the convention. A crucible furnace for burning petroleum was described.

The Worthington Condenser.

DECEMBER 21. Water Tube Boilers. The U. S. Cruiser New York.

Her final trial.

The Depression in Shipping Interests Abroad. The Tesla Engine.

DECEMBER 28. Practical Application of the Pyrometer.

JOURNAL OF THE AMERICAN SOCIETY OF NAVAL ENGINEERS.

VOLUME V., No. 4, NOVEMBER, 1893. Digest of Professor Cecil H. Peabody's Experiment with the George F. Blake Manufacturing Company's Pumping Engine Supplying Potable Water to the City of Newton, Mass., by Chief Engineer Isherwood, U. S. Navy. The Contract Trials of the U. S. Gunboats Machias and Castine. Modern Cranes.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

VOLUME XII., No. 10, OCTOBER, 1893. Light House System of the United States.

No. 11, NOVEMBER. Light House System of the United States. Modern Gun Making, by W. H. Jaques.

JOURNAL OF THE FRANKLIN INSTITUTE.

OCTOBER, 1893. Thermal Analysis of a Tandem Compound Engine. Carborundum. Anti-Friction Ball Bearings and their Manufacture. Artesian Wells.

NOVEMBER. The Storage Battery Question. The Methods of Testing Fats and Oils. Some Interesting Peculiarities of the Alternating Arc Lamp. H. S. K.

DECEMBER. On Light and Other High Frequency Phenomena, by Nikola Tesla (concluded). The History and Modern Develop-

ment of the Art of Interchangeable Construction in Mechanism, by W. F. Durfee. The Methods of Testing Fats and Oils. Notes on Recent Developments in Electricity Abroad, Part I. Charles A. Coulomb, by Prof. Edwin J. Houston.

JOURNAL OF THE UNITED STATES ARTILLERY.

VOLUME II., No. 4, OCTOBER, 1893. Notes on Armor, by First Lieutenant Erasmus M. Weaver, R. Q. M., Second Artillery, U. S. A.

It is the intention of the writer, after a brief review of the subject of armor in general, to present in the Journal, from time to time, such facts and information pertaining to armor as may come to his notice and be suitable for publication. To the end that the notes may be full, he asks contributions from all those who may be interested. Information in this line addressed to him at Fort Adams, Newport, R. I., U. S. A., will be gratefully received and duly acknowledged.

Artillery Difficulties in the Next War, by First Lieutenant John W. Buckman, First Artillery, U. S. A. Notes on Confederate Artillery Instruction and Service, by Professor M. W. Humphreys, University of Virginia. Hadfield's Manganese Steel and Chromium Steel Projectiles, by Captain Edmund L. Zalinski, Fifth Artillery, U. S. A. The Artillery Fire Game (translation). Field Manœuvres of Artillery Masses and the Instruction to be Drawn Therefrom (translation from *Revue d'Artillerie*). Notes on Artillery.

JOURNAL OF THE UNITED STATES CAVALRY ASSOCIATION.

Employment of Cavalry in War. Chapters from "Organization and Tactics."

MINUTES OF PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS.

VOLUME CXIII., 1892–93, PART III. Plant for Harbor and Sea Works. The Break-Down of the R. M. S. Umbria. Radial Valve-Gears: Analysis of the Motion of the Valve. A Method of Testing Engine Governors. Experiments on the Strength of Portland Cement Concrete. A New Method of Designing Wheel-Teeth. The Chinipas Aqueduct and Mineral Railway, Northwest Mexico. Hydraulic Work on the Irawadi Delta. The Chenab Weir. Note on the Flow off a Catchment Area near Mercara, South India. Scherer's Logarithmic Graphic Calculator.

The calculator can compete in accuracy with a table of four-place logarithms.

The Variation in the Economy of the Steam Engine Due to Variation in Load. Inexplosible Steam Boilers. Anchor Equipment of Warships and Recent Trials of Anchors in the Imperial

(German) Navy. The Application of Aluminum and its Alloys to Naval Construction. Electrical Resistance of Commercial Copper. On a New Electrometer.

VOLUME CXIV., 1892–93, PART IV. Steam Engine Trials. Wreck Raising in the River Thames. The Interdependence of Abstract Science and Engineering. The 160-Ton Hydraulic Crane at the Malta Dockyard Extension Works. On the Manufacture of Modern Fixed Ammunition. The Manufacture and Efficiency of Armor Plates.

REPORT OF THE PROCEEDINGS OF THE NUMISMATIC AND ANTIQUARIAN SOCIETY OF PHILADELPHIA, 1887–1889.

On April 5, 1888, Mr. Stewart Culin exhibited a photograph of a Chinese breech-loading cannon now in the collection of trophy guns at the Artillery School, Fortress Monroe. This interesting weapon was captured in Corea in 1861 by the squadron of Rear-Admiral Rodgers. It is a bronze wall-piece, with a calibre of 1.44 inches. The barrel is 18.62 inches long, and the breech-loading cavity 10.04 inches. Upon one side of the breech is an inscription composed of 51 Chinese characters of an ancient style, a copy of which was exhibited to the Society. This inscription gives the name of the official superintending the casting, of the officer of the artillery department, of the district magistrate, and of the smith who manufactured the gun, together with its official designation, "4th class *fu ran chi*, number 194," and its weight, 100 catties, or about 133 pounds. The date is inscribed as the *kwei ch'au* year, 8th month, — day, but as the characters *kwei ch'au* only indicate a particular year, the fiftieth, of the cycle of 60 years, and no regnal period is given, they are not sufficient to fix the age of the piece. The Chinese Minister, in a communication to Secretary Bayard under date of July 29, 1886, states that the titles of the military officials upon the casting are those created during the Yuen dynasty, during which the year indicated by the cyclical characters corresponded with A. D. 1312, a date more remote than has hitherto been accorded to such firearms.

On October 4, Mr. Culin made another communication with reference to the Chinese breech-loading cannon at Fortress Monroe, in which he stated that the characters *fu ran chi* on the breech simply designated it as a *Frangee*, or Frank gun, and that the titles of the military officials of the Yuen dynasty upon which the opinion as to its remote antiquity was based, were still used, on the eminent authority of Mr. Satow, in Corea where the gun was captured. These facts, with those already elicited, were considered by Mr. Culin to establish a comparatively modern period for the gun.

[There is another at the Naval Academy; such guns are very common in Corea.]

STEVENS INDICATOR.

VOLUME X., No. 3, JULY, 1893. The Chemical and Physical Examination of Portland Cement. Investigation of the Losses of Pressure of Compressed Air and of Steam in Pipes. The Electrical Engineer and His Relation to Mechanical Engineering.

No. 4, October. Lecture Notes. Mechanical Integrator. A simple Geometrical Proof for the Zeuner Diagram. The Chemical and Physical Examination of Portland Cement.

TECHNOLOGY QUARTERLY, AND THE PROCEEDINGS OF THE SOCIETY OF ARTS.

Volume VI., No. 2, July, 1893. The Fire Hazards of Electricity. Fire Risks and Electric Wires. The Blower System of Heating and Ventilation. College Athletics. Additional Notes on the Prismatic Stadia Telescope.

TRANSACTIONS OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS.

Volume XXVIII., March, 1893. Jetty Harbors of the Pacific Coast.

May. Jetty Harbors of the Pacific Coast (discussion).

June. Erosion of River Banks of the Mississippi and Missouri Rivers.

Volume XXIX., July. Navigation Works Executed in France from 1876 to 1891. History of the Conversion of the River Clyde into a Navigable Water Way, and of the Progress of Glasgow Harbor from its Commencement to the Present Day. A Brief Account of the Building of Leixoes Harbor. The Limits Attainable in Improving the Navigability of Rivers by Means of Regulation. The Improvement of Harbors on the South Atlantic Coast of the United States.

Volume XXX., October. Topographic Surveys. Recent Experiments of the U. S. Coast and Geodetic Survey in the Use of Long Steel Tapes for Measuring Base Lines. Terrestrial Magnetism in North America, by Charles S. Schott, Assistant U. S. Coast and Geodetic Survey. Fundamental Units of Measure, by T. C. Mendenhall, Superintendent U. S. Coast and Geodetic Survey. Historical Notes Upon Ancient and Modern Surveying and Surveying Instruments. The Treatment of Metals for Structural Purposes, by James Christie, M. Am. Soc. C. E. The Use of Mild Steel for Engineering Structures; The Use of Basic Mild Steel as Material for Construction in Germany. J. H. G.

FOREIGN.

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE.

XXI., Annual Series, 1893, Volume VIII. Report on the Sixteenth Competitive Test of Marine Chronometers Made at the German Observatory in the Winter of 1892–93. Contributions to the History of Ocean Sailing Directions (conclusion). Drift Ice in

Southern Latitudes (conclusion). Voyage of the German Cruiser Schwalbe from Zanzibar to Aden. Voyage of the German Cruiser Sperber from Sydney to Apia. Extracts from the Cruising Report of the Captain of the German Schooner Coquette. Harbors and Voyages on the West Coast of South and Central America, Guayaquil and Manta, Ecuador, Flores, Azores. The Harbor of Cienfuegos, South Coast of Cuba. Minor Notes: Experiments with Unmanned Balloons in High Altitudes; The Effect of Soapy Water on the Waves; Illuminated Clouds; Breakers Near the Cliff Marambaya, to the Eastward of Ilha Grande, Coast of Brazil.

Meteorological Journals received at the German Observatory in July, 1893.

The Weather on the German Coast in July, 1893 (with tables).

Volume IX. Researches in the Magnetic Conditions of Teneriffe Island (with chart). Voyage of the German Gunboat Hyäne from Kameroon to St. Paul de Loando. Voyage of the German Cruiser Falke from Kameroon to Freetown. Voyage of the German Gunboat Iltis from Shanghai to Nagasaki, thence to Kobe. Voyage of the German Cruiser Arcona from Cape Town to Whale Bay, Rio, Sâo Francisco and Montevideo. Gorontalo and Batui in the Celebes Islands. Sangir Islands. Voyage from Gorontalo to the Indian Ocean. Harbors and Passages in the Bismarck Archipelago. New Reef Discovered in the Steffen Straits. Voyage from Hamburg to Hong Kong. Notes on Delagoa Bay, South Africa, and Port Augusta, South Australia. Notes on the Gulf of Nicoya, Central America, and on Harbors in the Gulf of California. Falmouth Harbor, Jamaica. Minor Notes: A Peculiar Fish; Southern Light Observed in the Indian Ocean; Waterspout in the South Atlantic; Illuminated Clouds in the North Atlantic Ocean.

Meterological Journals received at the German Observatory in August, 1893.

The Weather on the German Coast in August, 1893 (with tables). H. O.

BOLETIN DEL CENTRO NAVAL.

Volume XI., August, 1893. Modern Constructions (continued. See page 616, Volume X). The New Armament for Infantry.

It is a brief history of the modern small-calibre guns in use in different armies.

The Armament of the Chilian Armored Battleship Capitan Prat (Marine de France). J. L.

DEUTSCHE HEERES-ZEITUNG.

August 26, 1893. The Losses in the Principal Battles of the Past Hundred Years. Numerical Preponderance in the Battles of the Future (continued). Military Notes. Naval Notes.

AUGUST 30. The Mechanical and Intellectual Training of the Soldier (a study). Numerical Preponderance in the Battles of the Future (continued). Military Notes. Naval Notes.

SEPTEMBER 2. Numerical Preponderance in the Battles of the Future (conclusion). The Use of Disinfectants in Military Barracks. Military Notes. Naval Notes.

SEPTEMBER 6. The Grand Manœuvres of the Second and Third Army Corps of the French Army. The Use of Disinfectants in Military Barracks (continued). Military Notes. Naval Notes.

SEPTEMBER 9. The Battle Near Montford, January 8, 1871. The Use of Disinfectants in Military Barracks (conclusion). Military Notes. Naval Notes.

SEPTEMBER 13. Smokeless Powder. Military Notes. Naval Notes.

SEPTEMBER 16. The German Garrison Church. Regulations for the Italian Grand Manœuvres. Regulations for the French Grand Manœuvres. Military Notes. Naval Notes.

SEPTEMBER 20. General Miribel. Strategy in Naval War. Military Notes. Naval Notes.

SEPTEMBER 23. General v. Löe, of the German Army. Strategy and Mobilization. Military Notes. Naval Notes.

SEPTEMBER 27. Instructions of General Du Guiny to the Third French Army Corps for the Grand Manœuvres. Military Notes. Naval Notes.

OCTOBER 1. The Austrian Cavalry, General v. Edelsheim Gynlai. The Value of Conserves to an Army. Military Notes. Naval Notes.

OCTOBER 4. The Value of Conserves to an Army (continued). Military Notes. Naval Notes.

OCTOBER 7. The Value of Conserves to an Army (conclusion). Military Notes. Naval Notes.

OCTOBER 11. The Loss of the Russian Monitor Russalka in the Baltic. A Criticism of the Monitor Type of Vessel. Comments on the Autumn Manœuvres of 1893. Military Notes. Naval Notes.

OCTOBER 14. The Late General von Versen, of the German Army. Comments on the Autumn Manœuvres of 1893. Military Notes. Naval Notes.

OCTOBER 18. The Late General von Kamecke, of the German Army. Comments on the Autumn Manœuvres of 1893 (conclusion). Military Notes. Naval Notes.

OCTOBER 25. Russian Military Life, as it Is, and as it Should be. Belgium and Switzerland as Neutral Military Powers. Military Notes. Naval Notes.

OCTOBER 28. The Wars of Frederick the Great. Belgium and Switzerland as Neutral Military Powers (continued). Military Notes. Naval Notes.

NOVEMBER 1. How Manœuvre the Large Armies of the Present Day? Belgium and Switzerland as Neutral Military Powers.

NOVEMBER 4. The Present German Infantry Tactics in the Light of Battles around Metz in 1870. Belgium and Switzerland as Neutral Military Powers. H. O.

THE ENGINEER.

VOLUME LXXVI., No. 1967, SEPTEMBER 8, 1893. The New Cruisers Powerful and Terrible.

Designed to have a displacement of 14,000 tons, be sheathed and coppered, and have a speed of 20 knots.

Late Additions to the French Navy.

No. 1968, SEPTEMBER 15. The New Battleships.

The Majestic and Magnificent, designed with a displacement of 14,900 tons each.

Trial of Schneider's Nickel Steel Armor for Russia. The Devastation.

No. 1969, SEPTEMBER 22. The Russian Battleship Twelve Apostles. The Trials of H. M. S. Devastation.

No. 1970, SEPTEMBER 29. United States Warships and War Material. Steam Life Boat with Hydraulic Propellers.

No. 1971, OCTOBER 6. French Naval Construction. A Torpedo-Ship. H. M. S. Speedy.

No. 1972, OCTOBER 13. The Cunard Company's Steamship Lucania.

No. 1973, OCTOBER 20. American Nickel Steel Armor Plates. Ships of War, Large and Small. Induced Draught in Marine Boilers. Proposed Torpedo-Ship Turtle. The Laval Steam Turbine.

No. 1974, OCTOBER 27. Miscellanea: Relating to New Suez Canal Regulations and to the Building of an Armed Service Steamer by the Canadian Government. Ship Resistance and Tank Experiments. Second-Class Battleship Admiral Nachimoff. H. W. J.

No. 1975, NOVEMBER 3. Shipbuilding in America. Lighting Tidal Channels. Krupp's Guns and Mountings at the Chicago Exposition. The Foundering of the Victoria. The Mersey Bar. Naval Manœu-

vres in 1892. Casualties on Board Ships of War. The Relative Merits of Working Hoisting Machinery by Steam, Water and Electricity.

No. 1976, NOVEMBER 10. H. M. S. Speedy. The Loss of H. M. S. Victoria. Captain Neale's Apparatus for Signaling Under Water. Trials of H. M. S. Hebe. Gas Engine Development—A 600-Horse-Power Engine.

No. 1977, NOVEMBER 17. H. M. S. Victoria. Admiralty Models, Illustrating the Loss of the Victoria; Admiralty Minute on the Question of Closing Watertight Doors, etc. The following extract from the latter explains itself:

"In conclusion, their Lordships are of opinion that the general structural arrangements of the Victoria—similar in many respects to those of other ships in her Majesty's Navy—with the arrangements of water-tight doors, armored belt, and protective deck, did not by any fault of principle contribute to the loss of the ship; but that, on the contrary, had the water-tight doors, hatches, and ports been closed, the ship would have been saved, nothwithstanding the crushing blow which she received from the Camperdown."

Trial of a Yarrow Water-Tube Boiler. H. M. S. Hood.

"The Hood is undoubtedly the noblest specimen of a turret ship that has been hitherto produced."

No. 1978, NOVEMBER 24. The Bethlehem 125-Ton Hammer. The Italian Battleship Sardegna. Trials of H. M. S. Barfleur and Revenge.

These vessels are first-class battleships.

No. 1979, DECEMBER 1. Admiralty Ferrules. Artillery Experiments at Elswick. The Manchester Ship Canal. The Bruges Maritime Canal. Lord Charles Beresford's New Naval Programme. Trials of H. M. S. Royal Oak. Launches of H. M. S. Daring and Dryad.

The Daring is designated a torpedo-boat destroyer, with an estimated speed of 27 knots, and the Dryad as a first-class torpedo gunboat, with a speed (estimated) of 19¼ knots.

The Efficient Protection of Iron and Steel from Chemical Action.

Red lead was held to be the best protection.

No. 1980, DECEMBER 8. The New Torpedo-Boat Destroyer Havock.

No. 1981, DECEMBER 15. Torpedo-Boat Destroyers. Launch of H. M. S. Forte.

No. 1982, DECEMBER 22. Debate on the Navy. A New Explosive (Fulgurite). Trials of H. M. S. Theseus.

No. 1983, DECEMBER 29. New Type Torpedo-Boat.

"While going to press with our last issue, No. 93, the first of the new type of torpedo-boats ordered in 1892, designed by Mr. W. H. White, C.B., Director of Naval Construction, and built and engined by Messrs. Jno. I. Thornycroft & Co., of Chiswick, was completing her trials off Sheerness, at which the usual Admiralty officials attended. The runs on the mile were made on the 14th inst., and gave the following mean results: With steam at 225 lbs. pressure per square inch, the engines made 472 revolutions per minute, giving the ship a speed of 23.85 knots. On the three hours' continuous run on the 21st inst., 467 revolutions per minute were made by the engines, and the speed of ship by log was 23.5 knots. The new type torpedo-boats are 140 ft. long, 15 ft. 6 in. beam, and their loaded draught 5 ft. 4 in. No. 93 is the only one ordered to be fitted with twin screws. She has three cylinder triple-expansion engines of 2000-horse-power, supplied with steam by two Thornycroft water-tube boilers. The vessel is armed with three 3-pounder guns, and fitted with three 18-in. torpedo-tubes."

ENGINEERING.

VOLUME LVI., No. 1445, SEPTEMBER 8, 1893. The Engineering Congress at Chicago (continued). The Pathology of the Steam Engine. The Damage to H. M. S. Howe. Fast Ocean Steamships (concluded). The La Guaira Harbor Works, Venezuela.

No. 1446, SEPTEMBER 15. Nickel Steel Armor Trials at Creusot. H. M. First-Class Cruiser Theseus. The Waste of Shipping. The New Spanish Cruiser Infanta Maria Teresa. Induced Hot-Air Draught in Boilers with Serve Tubes. Launches and Trial Trips.

The mean speed of H. M. S. Resolution, first-class battleship, by the Cherub log was 17.92 knots.

Official Tests in Norway with Small-Calibre Rifles.

No. 1447, SEPTEMBER 22. Electric Forging. The Engineering Congress at Chicago (continued). Launches and Trial Trips.

The double turret ship Devastation which has been provided with modern triple-expansion engines, on a full power trial for four hours made a speed by patent log of 14.56 knots.

No. 1449, OCTOBER 6. The Engineering Congress at Chicago (continued). 90-Inch Gun Lathe, World's Columbian Exposition.

No. 1450, OCTOBER 13. The Engineering Congress at Chicago (continued). Launches and Trial Trips.

No. 1451, OCTOBER 20. Steam Trials of the Spanish Cruiser Infanta Maria Teresa.

No. 1452, OCTOBER 27. Launches and Trial Trips.

No. 1453, NOVEMBER 3. The Institution of Mechanical Engineers. The British Association. The Engineering Congress at Chicago. Napier's Steam Steering Gear. Modifications of Carbon in Iron.

No. 1454, November 10. The Institution of Mechanical Engineers (concluded). The Marseilles and St. Louis Electric Road Railway. The British Association (concluded). The Engineering Congress at Chicago. H. M. S. Victoria; Arrangement of Bulkheads and Watertight Doors.

No. 1455, November 17. The National Danger. Refrigerator Car at the World's Columbian Exposition. The Engineering Congress at Chicago. Diagonal Compound Surface Condensing Engines of S. S. Fairy Queen. The Torpedo Gunboats. New Smokeless Powder.

"Plastomenite" is the name given to a new kind of smokeless powder invented by a German, Herr W. Güttler. The solution is poured into forms, where it becomes a fairly hard substance, capable of being pressed, rolled, etc. The substance can be colored at will, and is, like celluloid, serviceable for numerous purposes. Plastomenite is used for blasting powder, powder for cannons and rifles, signal rockets, etc. The greatest advantage claimed for it is complete durability, whilst all other smokeless powders, manufactured by the means of ether and nitro-glycerine, invariably deteriorate. The combustion of plastomenite is also, it is claimed, so well balanced that it leaves no residue in barrel or cartridge, although the striking velocity of the projectile is unusually great. The initial velocity from 6½-mm. calibre is 715 m., with a gas pressure of considerably below 3000 atmospheres. It is said that neither cold nor hot weather has any effect upon the plastomenite cartridges, whereas all powders containing nitro-glycerine suffer from changes in the temperature. Hitherto plastomenite has principally been manufactured for sporting purposes, but its good qualities have attracted the attention of the German military authorities, and it will now be extensively tested in the army.

The Brown Segmental Wire Gun.

No. 1456, November 24. The Engineering Congress at Chicago (concluded). 3000 Horse-Power Quadruple-Expansion Engines, World's Columbian Exposition. Stability of Ironclads. Our Battleships. Flash-Lights in Lighthouses.

No. 1457, December 1. Water-Tube Boilers of H. M. S. Daring. Indicator Diagrams on a Time Base for Steam and Gas Engines. Triple-Expansion Engines for Turkish Gunboats. The Capsizing of a Torpedo-Boat.

No. 1458, December 8. The Fastest Cruiser in the World (the Columbia).

No. 1459, December 15. Battleship Steam Trials. Additions to the British Navy.

The Naval Construction and Armaments Company have received orders from the Admiralty to build three torpedo destroyers of the Havock type. These boats have a displacement of 230 tons, 4000 horse-power, and a guaranteed speed of 27 knots. The Torch and Alert belong to an entirely new class of gunboats, and will be built from the designs of Mr. W. H. White, C. B., Director of Naval Construction. They are to have a length

of 180 ft., a breadth of 32 ft. 6 in., and a mean load draught of 11 ft. 6 in. They will have a displacement of 960 tons, and will be fitted with machinery of 1400 horse-power under forced draught, and 1050 horse-power under natural draught; with a speed of 13.25 knots and 12.25 knots respectively. Their armament will consist entirely of quick-firing guns, each carrying six 25-pounders and four 3-pounders.

No. 1460, December 22. A New Peru. Steam Boiler Experiments. Engines of the Italian Cruiser Aretusa. The Debate on the Navy. The Evolution of the Atlantic Greyhound. Shipbuilding and Marine Engineering in 1893. The American Navy.

No. 1461, December 29. A New Peru. The American Society of Naval Architects.

Extracts from papers presented by Ex-Chief Constructor T. D. Wilson, U. S. Navy, and Engineer-in-Chief G. W. Melville, U. S. Navy.

Table Showing Expenditures of Coal on U. S. S. Charleston at Various Speeds. Warship Building. Electrical Signaling by the Telephotos. J. H. G.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION.

No. 187, September 15, 1893. The Handling of Masses of Artillery. The Phonograph and its Application to Military Purposes. Recent Progress in Marine Machinery. German Instructions for Field Fortifications. Naval and Military Notes.

No. 188, October 15. Dress and Equipment, with Practical Illustrations. Coal Consumption of Ships of War.

An interesting paper on a very important subject.

Mobilization for Home Defense. French Naval Manœuvres of 1893. Naval and Military Notes. Recent Naval Literature. Coast Artillery Practice. Tactical Deductions from the Recent Skeleton Exercises Near Reading. The Italian Naval Manœuvres of 1893.

No. 189, November 15. The New German Army Bill.

The German Army will in future consist of:

538 battalions and 173 half battalions of infantry.
465 squadrons of cavalry.
494 batteries of field and horse artillery.
37 battalions of foot artillery.
23 battalions of pioneers.
7 battalions of railway troops.
21 battalions of trained troops.

These are formed in peace times into 20 army corps, each of two divisions, with the exception of 4 corps, in each of which there are 3 divisions. The following figures give the actual numbers of the German Army under the provisions of the New Army Bill:

Men	479,229
N. C. O.'s	77,864
Officers	22,455
One year volunteers (say)	9,000
Total combatants	588,548
Medical officers	2,068
Paymasters	1,102
Veterinary Surgeons	578
Armorers, Saddlers, etc	1,153
Total	593,449

No. 190, December 15. Discussion of the Military Prize Essay, 1893. Proposed Mariners' Compass Card Marked in Degrees only. The Lephay Luminous Compass. The Whitehead Torpedo and its Relation to Modern Armaments and Tactics. Naval and Military Notes.

MÉMOIRES DE LA SOCIÉTE DES INGÉNIEURS CIVILS.

Forty-Sixth Year, August, 1893. Research into the Causes of Accidents in Multitubular Boilers. Notes upon Polyphased Alternate Currents. The Auriferous Beds of Italy.

September. The Societé des Ingénieurs Civils During the Siege of Paris. Chronicles No. 165, by M. A. Mallet. Comptes Rendus.

J. L.

MILITÄR WOCHENBLATT.

August 30, 1893. Increasing the Interval Between Pieces, and Mixing Different Commands of Field Artillery. Prof. Hebler's Light and Heavy Bullet.

September 2. Target Practice in the Altwater Mountains, Austria. Practice Ammunition of the French Artillery.

September 6. The Family von Rauch in the Prussian Army. Review of the Latest Inventions and Discoveries in the Military and Technical Fields (continued). Aluminum Cooking Utensils for Field Service.

September 9. Review of the Latest Inventions and Discoveries in Military and Technical Fields (continued). New Regulations for the Distribution and Service of Officers of the Cossack Regiments.

September 13. Sanitary Report of the Bavarian Army, from April 1, 1889, to March 31, 1891. Turkish Irregular Cavalry.

September 27. Cavalry Manœuvres in Peace.

October 4. Rifled Breech-Loading Mortars in the United States. A description of the 12-in. Mortar for Coast Defense.

October 7. Observations on Artillery Manœuvres. The Grand Manœuvres near Krassnoe, Selo. Voluntary Target Practice in Switzerland.

October 11. Comments on the German Manœuvres in Alsace and Lorraine. Portable Tent Equipment for the Austrian Army.

October 14. Comments on the German Manœuvres in Alsace and Lorraine (continued). English Torpedo-Boat Destroyers.

A review of the different classes of torpedo-boats built in England, in recent years, and a description of the latest type, the Havock.

October 25. Comments on the German Manœuvres in Alsace and Lorraine (continued). The New Regulations for Infantry Fire in the German Army. The Acquirement of the Russian and Polish Languages by German Army Officers.

October 28. The New Regulations for Infantry Fire in the German Army (conclusion).

November 1. Comments on the German Army Manœuvres in Alsace and Lorraine (continued).

November 4. The French Manœuvres of 1893. The Use of Machine Guns by the Swiss Cavalry. Redistribution of the Spanish Army.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

Volume XXI., Annual Series 1893, Nos. 8 and 9. The Torpedo and Rapid-Firing Guns of Large Calibre (a study). The Victoria Court Martial.

A full account of the proceedings of the court.

New Regulations for the Training of Gunners for the French Navy. The Allen Ice Machine. The German Naval Budget for 1894. The Italian Naval Budget for 1894. The American Naphtha-Boat, Constructed on the Morris System. Spontaneous Combustion of a Cargo of Coal on Board the English Bark Homesfeld. Tests of Armor for the U. S. Navy. Ammunition-Hoists for Rapid-Firing Guns. Nickel Steel Armor in Russia. The Ocean Voyage of the Viking Ship. Notes on the U. S. Navy. Speed Trials of French Torpedo-Boats. Submarine Boats. Subsidies for the Hungarian Merchant Marine. New Programme for the Examination of Officers of the French Merchant Marine and Yachts. Organization of the Fleet and Squadron Staffs in the French Navy. Qualified Torpedo-Officers in the French Navy. Recent Constructions in Torpedo Vessels in England. Placing Light-Keepers under Military Control in France. The Steam Life-Boat Duke of Northumberland. The Loss of the Brazilian Cruiser Almirante Barroso and of the Russian Cruiser Vitjaz. The Use of Oil at Sea. A New

Type of Vessels with Central Propeller. The Adoption of Mineral Oils or Electricity for Running Lights in the French Navy. Machine Oil in the French Navy. The Voyage of the three Caravels from Havana to New York. Testing Armor-Plates in the United States. Reorganization of the Italian Ministry of Marine. Seamless Steel Boats. The Russian Inland and Coast Shipping. The Italian Protected Cruiser Liguria. Torpedo Tests in the Harbor of Toulon, France.

No. 10. The Torpedo and Rapid-Firing Guns of Large Calibre (a study; conclusion). On the Relative Accuracy of the Theodolite and Sextant Time Observations.

A review of the trials of changes and inventions in, etc.

Ships' Armor and Marine Artillery or Naval Ordnance. Lloyd's Rules for Electric Light Installation on Board Ship. Whitworth Recoil Check on Board the Devastation. The Naval Expenditures of the Different Sea Powers. The French Battleship Charles Martel. The French Torpedo Dispatch Boat D'Iberville. The French Torpedo-Cruiser Mousquetaire. The New English Battleships Majestic and Magnificent, and Cruisers of the First-Class. The Trial of the Battery of the English Battleship Ramillies. The Distribution of the Italian Warships on the Italian Coast. Submarine Boats in the United States. A Hydro-Pneumatic Ash-Ejector.

No. 11. The English Fleet Manœuvres of 1893. The French Fleet Manœuvres of 1893. The Forcible Entrance of the French Warships Inconstant and Comete into the Ménam River. Submarine Boats. The Effect of Changes in Screw-Propellers on the Speed of Vessels. The Fortifications of the Harbor of Spezia, Italy. Semaphore Signal Stations on the Italian Coast. The U. S. Cruiser Minneapolis. French Patrol-Boats for Use in the Upper Mekong. The French Protected Cruiser D'Entrecasteaux. The French Torpedo-Cruiser Lansquenet. Accident on Board a French Torpedo-Boat. The English Turret-Ship Devastation. Trial of the English Torpedo-Cruiser Renard. Changes in the Turkish Navy. The New Cruiser Blanco Encalada for the Chilean Navy. Proposed Increase of the Japanese Navy during the Coming Year. The Spanish Cruiser Infanta Maria Teresa.

The result of her trial under natural draft: she attained a mean speed of 18.48 knots; .48 knots above the contract speed.

Launch of the Russian Torpedo-Boat Tossna. The Loss of the Russian Monitor Rusalka, and of the Haytian Despatch Boat Alexandre Petian. Grounding of the English Battleship Camperdown in the Entrance to Malta. Tests of the Armor Plates for the Russian Armored Ship Tri Sojatitelja. Cost of Harveyized Armor Plates. Rearrangement of the German Coast into Districts.

The German coast is divided into six districts, each under a naval officer as inspector.

The Results which will follow the Opening of the North Sea and Baltic Canal. Raising Sunken Vessels by Means of Air-Bags. New Dry-Docks at Portsmouth, England. H. O.

LE MONITEUR DE LA FLOTTE.

No. 46, November 18, 1893. The Naval Defense Act.

This is a comment by M. Marc Landry upon several articles that have lately appeared in the *London Times*, of which the motives are very apparent to the author and the naval world in general.

The Navy on the Niger. The Issue to the Fleet of the Berthon Life Boats. The Policy of England.

A supplementary article exposing the schemes of Great Britain to neutralize French colonial developments in Madagascar, Newfoundland, etc., by M. De Mahy, Vice-President of the French Chamber of Deputies.

No. 47, November 25. The Chiefs of Staff Question.

No. 48, December 2. The French Navy. The Policy of England in Egypt, Madagascar, Newfoundland (continued). J. L.

PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENNEERS.

No. 1, February, 1893. Description of the Experimental Apparatus and Shaping Machine for Ship Models at the Admiralty Experiment Works, Haslar, by Mr. R. Edmund Froude.

No. 2, August. On Recent Developments in the Cleveland Iron and Steel Industries.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

Volume XX., No. 9, September, 1893. Adjuncts of Defense. Horses' Snow Shoes. A Proposed Method of Firing at Moving Objects at Moderate Ranges. Memoirs, Historical and Biographical. Penetration and Effects of Projectiles on Earth and Masonry.

No. 10, October. Journal of Major George Brooke, 1st Brigade, Bengal Horse Artillery, 1838. Royal Trophy Guns at Windsor. Tactical Problems. Self-adjusting Firing Lanyard for Field Artillery. Siege of Minorca—by an Officer who was Present at the Siege. Translation of "Tactical Observations," by General Dragomirov.

No. 11, November. A Proposal for the Supply of Ammunition in the Field. Note on Infantry Tactics. Siege of Minorca, 1756, by an Officer who was Present at the Siege (concluded). Lectures for N. C. O. and Men of Field Artillery.

No. 12, December. A Visit to Aspern and Wagram.

Being an account of the passage of the Danube by Napoleon in 1809.

Some Notes on Naval Gun Drill and Practice. Clipping of the Troop Horses. Army Schools. Horse Artillery Guns at Waterloo.

J. H. G.

REVISTA TECNOLÓGICO INDUSTRIAL.

NÚM. 10, OCTOBER, 1893. Harmonic Valve Diagram. Descriptive and Rational Chemistry (end).

REVUE DU CERCLE MILITAIRE.

No. 32, AUGUST 6, 1893. The Mekong. Project of Reorganization of the Italian Army.

No. 33, AUGUST 13. The Normal Calibre of the Infantry Rifle. War-Dogs in the German Army. Project of Reorganization of the Italian Army (continued in Nos. 34 and 35).

No. 36, SEPTEMBER 3. New Firing Instructions for the Italian Army. The Normal Calibre of the Infantry Rifle (ended).

No. 37, SEPTEMBER 10. Our Naval Manœuvres as Judged by the English.

No. 38, SEPTEMBER 17. The Grand Manœuvres of 1893. The New German Regulations Concerning Field Fortifications. New Firing Instructions for the Italian Army.

No. 39, SEPTEMBER 24. The Grand Military Manœuvres of 1893 (with map, continued).

No. 40, OCTOBER 1. The System of Light Bridges for Infantry Troops (with sketches). The Grand Manœuvres of 1893 (with maps, continued).

No. 41, OCTOBER 8. The Grand Manœuvres, etc. (continued). New Firing Instructions for the Italian Artillery.

No. 43, OCTOBER 22. The Russian "Okhotniki," and Night Engagements.

No. 44, OCTOBER 29. The Problem of Mounted Infantry Solved by the Use of the Bicycle. The New German Regulations for Field Fortifications (continued). New Fire Instructions of the Italian Army.

No. 45, NOVEMBER 5. Drill of the Medical Corps Attached to the Government of Paris. The Irregular Troops of the Chinese Army.

No. 46, NOVEMBER 12. A Field Manœuvre for the Instruction of the Officers of the Reserve and of the Territorial Army.

No. 47, NOVEMBER 19. Spain in Morocco (with map). The Problem of Mounted Infantry Solved by the Use of the Bicycle (continued).

No. 48, NOVEMBER 26. Incorporation in Time of Peace of the Men Classified for Auxiliary Duties. The Irregular Troops of the Chinese Army (ended). The Problem of Mounted Infantry, etc.

No. 49, DECEMBER 3. Incorporation in Time of Peace of the Men Classified for Auxiliary Duties. The Problem of Mounted, etc., (ended).

REVUE MARITIME ET COLONIALE.

VOLUME CXVIII., No. 384, SEPTEMBER. Description and Theory of a Route Check (contrôleur de route). Plan of a Differential Counter, Registering in any Part of the Ship the Indications of the Valessie Counter. A History of Nautical Instruments. Gale observed on Feb. 20, 1879, at the Rochefort Naval Observatory. A Study of the Civil and Military Organization of China. A Plan of Route Signals in Thick Weather and Night Time. A Historical Study of the Military Marine of France.

No. 385, OCTOBER. Geometry of Diagrams. Economic Questions upon Indicator Curves. Geographical, Topographical and Statistical Notes on Dahomey. Exploration of the Magnetic Field in the Interior of Armored Conning Towers. A New Hydrographic Circle. Statistics of Wrecks and Other Mishaps at Sea for the Year 1891.

VOLUME CXIX., No. 386, NOVEMBER. Description of a Jury Rudder by the Captain of the S. S. Dom Pedro A Vocabulary of Powders and Explosives. Statistics of Shipwrecks and Other Casualties at Sea for the Year 1891 (ended). Development of the Merchant Marine of the German Empire.

RIVISTA DI ARTIGLIERIA E GENIO.

VOLUME III., JULY–AUGUST. An Account of Siege Operations from the Adoption of Modern Arms of Precision to the Year 1892. The School of Fire for Field and Siege Artillery. Project of a New Field-Tent Accommodating Four Soldiers.

SEPTEMBER. Operations Against Fortified Places (Reciprocal Conditions of Attack and Defense). Practical Hints in Regard to the Fire of Siege Ordnance. The Ammunition Supply and Service of Field Artillery. Mountain Warfare. Practical Questions. Field Artillery and its Action in Concerted Manœuvres with the Other Arms of the Service.

VOLUME IV., NOVEMBER. Mountain Warfare, etc. (with map, continued). Special Instructions for the German Foot Artillery. Influence of the New Means of Offense Against Temporary Field Fortifications. Brief Considerations on the Instruction in Position Taking by Batteries of Field Artillery. J. L.

RIVISTA MARITTIMA.

ANNO XXVI., No. 5, MAY 1893. Naval Architecture.

Graphic determination of the speed curves and graphic correction of friction. (A review and analysis of a paper read by Denholm Young.) 3 plates.

On the Laws of War.

General Ideas. The Declaration of War. Status of belligerent states towards each other. Rights and duties of belligerent states towards citizens of enemy's country. Rights over enemies' goods. Contraband of War. End of the war.

Naphtha and Torpedo-Boat 104 S (continued from preceding number).

Mechanical, steam and compressed-air pulverization of petroleum residuum.

The Arsenals of the Royal Marine, and Their Economical Government. Collection of the Works of Sir W. Froude, F. R. S., upon the Resistance to the Movement of Ships (continued from January, 1893). Popular Nautical Songs.

A brief account of Dibdin, Yaun Nibor and Gabriele d'Aumenzio, neither of whom represents the true folk-poetry of sailors.

Vocabulary of Powders and Explosives (continued). Chronicle: Argentine Independence; Austrian Manœuvres; New French Vessels; Experiments with Artificial Smoke to Mask Torpedo-Boats; New English Ships; Russian Notes on Armament; Expenditures; New Spanish Gunboats; Notice of the Vesuvius; English Submarine Torpedo Experiments; The Transmission of Heat Through Tube-Plates (trans.).

No. 6, JUNE. Defensive Maritime Centres, and Types of Ships.

Recapitulates the importance of naval arsenals in appropriate positions to command both basins of the Mediterranean, and the approaches to Italy from Suez and Gibraltar. Defines the principal duty of a fleet to be the ability to proceed quickly and offensively against enemy's territory, and outlines offensive operations against hostile material. Dominion of the sea a *sine qua non*. Advocates strongly fortifying naval centres. Advocates protected cruisers of not more than 2000 tons. Defends the heavily armored Italian types. Reviews the latest types of cruisers and torpedo-boats, etc.

Naphtha and Torpedo-Boat 104 S (continued). Recent Progress in Marine Engines (continued). Transatlantic Routes (with map). Chronicle: Launch of the Austrian Maria Teresa; French Torpedo-Boats; English Cruisers Powerful, Terrible, Magnificent and Majestic; Submarine Experiments; The Stranding of the Howe; Shipwreck of the Brigantine Italia; The First Unsinkable Ship.

No. 7, JULY. Aluminium; a Study of its Production, with several cuts of furnaces. Of Contraband of War. Elements of Thermo-Chemistry Applied to Explosives. New Explosives.

Collection of the Writings of Sir William Froude, F. R. S. on the Resistance to the Motion of Ships. The Loss of the Victoria. Chronicle: French Naval Estimates 1894; German Cruiser Gefion; English Cruisers Fox and Charybdis; Supply of Coal at Sea; Exercising the Torpedo-Boats at Maddalena, Italy; Launch of the Russian Armored Ship Admiral Seniavin; English Tests of Submarine Guns, and Conference Upon Armament of Ships.

Supplement. Budget of the Minister of Marine for 1893–94.

Status of the maritime forces; documents presented to the Italian Congress, and discussions on the expenditures and naval policy. Tables giving comparative strength of Italian and French ships. Numerical expression of the military power of a vessel.

Nos. 8 and 9, August, September. Oil Used to Calm the Waves.

Reviews the history of the whole subject, giving to our Hydrographic Office the credit of establishing the use of oil. Many examples of its modern use are given. Diagrams represent the best manner of using oil, of furnishing bags and pumps to spread it, and of its use in life-saving apparatus and torpedoes.

Historical Sketches of Ancient Monster Cannon. Aluminium (continued). Chronicle: Austrian Appropriation for 1894; Sketches of German Naval Manœuvres; The Loss of the Victoria: The De Frasseix Range Finder; Studies Upon the Chinese Typhoons; The Currents of the Atlantic; Bishop's Rock Lighthouse. F. S. B.

No. 10, October. Armor Plates for Ships (with cuts). Electro-Magnetic Affinities Between Some Cosmic, Telluric and Atmospheric Phenomena. About a Formula for Calculating the Average Indicated Power of Marine Steam Engines. Oils in Use for Stilling the Waves.

Supplement. The Cruiser Etna in Canada.

No. 11, November. The Seal Fishery in Behring Sea. Historical Notes Upon the Ancient Italian Compass Card. Humanitarianism and Loyalty in the Usages of War. The War of the Succession in Spain. Maritime Fiction; Marryat and Pierre Loti. Armor Plates for Ships (continued).

No. 12, December. Electric Ventilators. Armor Plates for Ships (with cuts, continued). The Seal Fishery in Behring Sea (end).

Supplement. The Cruise of the Yacht Corsaro in America.

A voyage undertaken by Captain d'Albertis, to complete by actual observations a work entitled "The Art of Navigation at the Epoch of Christopher Columbus." J. L.

STEAMSHIP.

Volume V., No. 52, October, 1893. Passing Events: Deterioration of Marine Boilers. The Lucania's Record. The United States

Armored Cruiser New York. Triple-Expansion Engines of the U. S. Revenue Steamer William Windom. Theory of the Mechanical Propulsion of Ships. The Testing of Boilers. Why Oil has an Influence on Waves. Electric Torpedo-Boats. The U. S. Protected Cruisers Columbia and Minneapolis. The New First-Class Cruisers (the Powerful and Terrible of 14,000 tons displacement).

No. 53, NOVEMBER. Passing Events : The Case of Marine Boilers ; Submarine Propulsion ; Torpedo-Boat Destroyers ; French Naval Preparations for War. Proposed New Form of Atlantic Steamship. Improvements in Dynamos and Motors. A New American Steam Steering Gear.

No. 54, DECEMBER. Passing Events : H. M. Torpedo-Gunboat Speedy ; Report of Engineer-in-Chief, U. S. Navy ; An Electrical Capstan. Evaporators and Feed Heaters for Marine Boilers. Induced Draught for Steamships. The U. S. Gunboat Castine. Launch of a Second-Class Cruiser (British, the Hermione). The Strength of Large Ships.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

VOLUME VI., PART I., MAY, 1893. The Use of Safe Explosives in Mines.

VOLUME VII., PART I., SEPTEMBER. A New Form of Steam Boilers. Transmission and Distribution of Power by Compressed Air.

TRANSACTIONS OF THE INSTITUTION OF NAVAL ARCHITECTS.

VOLUME XXXIV., 1893. On the Present Position of Cruisers in Naval Warfare, by Rear-Admiral Samuel Long, summarized as follows :

(1) There exists a class of cruisers analogous to battleships. These might advantageously be termed battle-cruisers.

(2) That speed and endurance are qualities of primary importance in cruisers, and should be associated with high freeboard.

(3) If a quantitative estimate may be hazarded, the minimum sea speed now acceptable should be 20 knots and the coal supply sufficient to last the minimum of seven days, 20 hours each day, at 10 knots and four hours at chasing speed, besides enough to proceed to and from the base at 10 knots and fight an action.

(4) That powerful cruisers at the end of a telegraph wire will be more conducive to sea power than numerous small ones, where ocean routes are concerned.

(5) That subsidies should be given to steamship companies for all vessels maintaining a sea speed of 21 knots.

(6) That the convoy of slow merchant steamers is likely to form an important feature of naval work in war, and would be a more effectual and

economical means of protecting trade, by insuring the simultaneous presence of war-ship and merchantman, than any other at present contemplated.

Merchant Cruisers; Considered with Reference to the Policy of Maintaining a Reserve of Vessels by Annual Subventions to Shipowners, by Right Hon. Lord Brassey, K. C. B. Some Considerations Relating to the Strength of Bulkheads. On the Measurement of Wake Currents. On the New Afonasieff's Formulæ for Solving Approximately Various Problems Connected with the Propulsion of Ships.

For practical purposes, $\left(\frac{v}{A}\right)^{\frac{10}{3}} D^2 = \frac{H}{1000} \sqrt[3]{\frac{L^2}{B}}$, where D is the displacement in tons, L the length between perpendiculars, B the breadth at the load waterline, H the indicated horse-power of the engines, v the speed in knots, and A a constant.

Some Experiments on the Transmission of Heat Through Tube Plates. Notes on Some Alterations of Form to Which Boilers Are Subject When Under Working Conditions. On an Apparatus for Measuring and Registering the Vibration of Steamers. A Method for Temporary Repairs of Fractures in the Iron Plates of Ships. On Approximate Curves of Stability. On Some Experiments With the Engines of S. S. Iveagh. On Working Triple-Expansion Engines as Compounds. The Cyclogram or Clock-Face Diagram of the Sequence of Pressures in Multi-Cylinder Steam Engines.

TRANSACTIONS OF THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

VOLUME IX., 1892–93. Combustion of Coal and Prevention of Smoke. Marine-Boiler Furnaces. Amount of Water Suspended in Steam. Ships' Electrical Fittings. Types and Proportions of Mercantile Steamers. Strains of Tank Steamers.

TRANSACTIONS OF THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

VOLUME XLII., PART III., MAY, 1893. The Geology and Coal-Deposits of Natal.

UNITED SERVICE GAZETTE.

No. 3166, SEPTEMBER 9, 1893. The Navy and the Spirit Question. The Sovereignty of the Seas. Our Guns. Rum in the Navy, II.

No. 3167, SEPTEMBER 16. The Krnka-Hebler Tubular Projectiles, IV. American Opinion of Our Naval Strength. The Admiralty and Engine-Room Artificers.

No. 3168, SEPTEMBER 23. The Admiralty Inspections. Naval Warrant Officers. Appropriation in the Lower Ranks of the Navy.

No. 3169, SEPTEMBER 30. Lord Armstrong on the Navy. Admiralty Inspections, II. Command of the Sea.

No. 3170, OCTOBER 7. Command of the Sea, II. Our Ship Building Policy. The British Army in 1892. The Home Defense Scheme.

No. 3171, OCTOBER 14. The Development of the Navy.

No. 3172, OCTOBER 21. Royal Naval College (Programme). Trafalgar. The Foudroyant.

No. 3173, OCTOBER 28. The Italian Navy. Imperial German Manœuvres in Alsace and Lorraine. Royal School for Naval and Marine Officers' Daughters. Our Greatest Need.

To strengthen the fleet.

No. 3174, NOVEMBER 4. The Loss of the Victoria. The Care of Our Wounded in War. General Brialmont on Corps D'Elite.

No. 3175, NOVEMBER 11. General Brialmont on Corps D'Elite, II. Imperial German Manœuvres in Alsace and Lorraine, II. The Education of German War Dogs. Our Naval Weakness. Army Examinations.

No. 3176, NOVEMBER 18. A French View of the Morocco Question. Volunteer Law and Administration. Our Present Naval Position. Our Naval Weakness, II. Field Works in Military Operations.

No. 3177, NOVEMBER 25. Our Naval Unpreparedness. Our Naval Weakness. Imperial German Manœuvres in Alsace and Lorraine, III. Ammunition Supply. Russia in the Northern Seas. Our Army and Military System.

No. 3178, DECEMBER 2, The Ideal Explosive. Stations of the British Army and Navy, corrected up to December 2. The Spanish Army, Its New Organization. Defense of Our Trade Routes. Official Optimism Regarding the Navy. Four Company Battalions.

No. 3179, DECEMBER 9. French and English Fleets in the Mediterranean. The Coming War. Torpedo Tests (of the Howell in the United States). The Naval Awakening. Hasty Defenses on the Battlefield.

No. 3180, DECEMBER 16. Our Naval Weakness. The United States Army. The Naval Awakening, II. The Empress of India.

No. 3181, DECEMBER 23. The French Navy. The Naval Debate. Bullets and Bacteria.

No. 3182, DECEMBER 30. Ship Building in the Royal Dockyards in 1893. Aerial Navigation, Has It Been Solved? Our Latest

Naval Success, The Havock. The Victoria Fund. Naval. Peace Promoters. Correspondence.

Naval armaments.

The Soldiers' and Sailors' Families' Association. J. H. G.

LE YACHT.

No. 806, AUGUST 19, 1893. The English Naval Manœuvres (E. Weyl).

One thing seems to have impressed the eye-witnesses to the manœuvres, and that was the inefficiency of the torpedo-catchers and torpedo-gunboats during the operations. Mishaps were of frequent occurence, and their speed at sea fell off from 40 to 30 per cent. of their speed on paper. In one word they were a constant source of anxiety to the fleet commanders. As a result of that inefficiency the English Admiralty decided to actively push forward the construction of torpedo-destroyers destined eventually to take the place of the catchers.

No. 807, AUGUST 26. Oceanography and Pleasure Navigation. Trials of the Plates of the Russian Armorclad Three Saints.

The trials took place lately at the polygon of the Creusot Works, and were highly satisfactory.

A Speed of Thirty Knots for Transatlantic Steamers.

No. 808, SEPTEMBER 2. Oceanography and Pleasure Navigation (Yachting).

No. 809, SEPTEMBER 9. The Loss of the Victoria in the House of Commons. The English Armored Vessels Magnificent and Majestic. An American Life Raft.

No. 810, SEPTEMBER 16. Submarine Torpedo-Boats; Their Rôle in Future Naval Wars. The New English Cruisers Powerful and Terrible.

No. 811, SEPTEMBER 23. The Command of Squadrons (E. Weyl).

As was natural, the loss of the Victoria brought out prominently in navy periodicals the question of evolutions at sea, and M. Weyl handles the subject with his customary skill and competency.

No. 812, SEPTEMBER 30. The Visit of the Russian Squadron. The Steam Yacht Feiseen, the swiftest boat in the world.

No. 813, OCTOBER 7. The Italian Navy Estimates (E. Weyl). A Coal Ash Ejector.

No. 814, OCTOBER 14. The Russian Squadron at Toulon. The America's Cup. The Valkyrie and Vigilant.

No. 815, OCTOBER 21. Reception of the Russian Squadron at Toulon. A New York Correspondence on the Cup Races. Preservation of Shafts on Ocean Steamers.

No. 816, OCTOBER 28. The Franco-Russian Fêtes. The Spanish Cruiser Infanta María Teresa. The French Cruiser Isly at Copenhagen.

No. 817, NOVEMBER 4. Visit of the President of the French Republic to Toulon, and Departure of the Russian Squadron.

No. 818, NOVEMBER 11. The Superstructures of Armored Battleships, and the Rapid-Fire Cannon. Rowing; Revision of the Race Code.

No. 819, NOVEMBER 16. Epilogue of the Loss of the Victoria. Aluminium in Ship Constructions; the Torpedo-Boat Ordered from Yarrow by the French Government. Protection of Iron Hulls by Means of Copper Electrotypic Coating.

No. 820, NOVEMBER 25. The Campaign in England in Favor of an Increase of the British Fleet (E. Weyl). Electric Motors of Continuous Currents.

No. 821, DECEMBER 2. A Campaign in England in Favor of an Increase of the British Fleet (continued). Commander Fleuriais' Double Reflection Micrometer. The New Table of Distances from Port to Port.

J. L.

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SPECIAL NOTICE.

NAVAL INSTITUTE PRIZE ESSAY, 1895.

A prize of one hundred dollars, with a gold medal, is offered by the Naval Institute for the best essay presented on any subject pertaining to the naval profession, subject to the following rules:

1. The award for the prize shall be made by the Board of Control, voting by ballot and without knowledge of the names of the competitors.

2. Each competitor to send his essay in a sealed envelope to the Secretary and Treasurer on or before January 1, 1895. The name of the writer shall not be given in this envelope, but instead thereof a motto. Accompanying the essay a separate sealed envelope will be sent to the Secretary and Treasurer, with the motto on the outside and writer's name and motto inside. This envelope is not to be opened until after the decision of the Board.

3. The successful essay to be published in the Proceedings of the Institute; and the essays of other competitors, receiving honorable mention, to be published also, at the discretion of the Board of Control; and no change shall be made in the text of any competitive essay, published in the Proceedings of the Institute, after it leaves the hands of the Board.

4. Any essay not having received honorable mention, may be published also, at the discretion of the Board of Control, but only with the consent of the author.

5. The essay is limited to fifty (50) printed pages of the Proceedings of the Institute.

6. All essays submitted must be either type-written or copied in a clear and legible hand.

7. The successful competitor will be made a Life Member of the Institute.

8. In the event of the Prize being awarded to the winner of a previous year, a gold clasp, suitably engraved, will be given in lieu of a gold medal.

By direction of Board of Control.

J. H. Glennon,

Lieut., U. S. N., Secretary and Treasurer.

Annapolis, Md., *January* 3, 1894.